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CHAPTER 188

Massachusetts Educational Assessment Program

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The Massachusetts Educational Assessment Program:

1988 Statewide Summary

MASSACHUSETTS DEPARTMENT OF EDUCATION

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— FOREWORD —

In 1987 the Board of Education accepted a set of nine goals for education in Massachusetts. The purpose of these goals is "to identify performance objectives for learners and suggest responsibilities for educators in giving life to those objectives."

Although the spirit of the entire set of goals is reflected in the Massachusetts Educational Assessment Program, those specific goals that are addressed by the program are listed below, with excerpts from the rationale that accompanied them.

Goal 2: Communication Skills

Education should develop in each learner the reading, writing, listening, speaking and computational skills necessary for effective communication, as well as the ability to think clearly and critically.

Learning can take place only if the individual is able to receive, interpret and respond to information effectively. The early learner has a natural inclination to acquire skills by imitating others. Schools should not only cultivate this inclination through sound instructional programs, but also develop students' evaluative and critical thinking skills and their ability to apply what they have learned.

The ability to think clearly and critically, to distinguish between fact and opinion, to express ideas creatively, and to use computers and other tools of technology are all essential to this goal. Education must address not only the basic skills, but must also provide each student with the opportunity to value communication as a personal and essential element in the human experience.

Goal 3: Citizenship in a Democratic Society

Education should provide each learner with knowledge and understanding of how our society functions, and foster individual commitment to exercise the rights and responsibilities of citizenship.

Teaching citizenship is the first duty of the common school. Citizenship in a democratic society requires effective participation in its political, economic and social institutions. Citizens can participate effectively when they understand how these institutions work, accept responsibility for living within and improving them, are familiar with methods of effecting change, and respect the rights of others in the community. Students should be taught and encouraged to practice these attributes of good citizenship in the school community no less than in the larger society.

Goal 6: Understanding History and the Humanities

Education should provide each learner with knowledge and understanding of history, the humanities, and our multicultural heritage.

Each student should understand history and the humanities as an integrated whole rather than a series of isolated subjects. The study of geography and its relationship to history is one essential component of this understanding, particularly as it makes students aware of their place in the world and the interdependence of all nations. The social sciences provide students with insight into the human motivations that underlie historical trends and milestones.

Education should provide each student with more than knowledge of historical events. It should help the student understand the effect of those events on different fields of human endeavor, and appreciate their significance for our world today.

Goal 7: Understanding Mathematics and the Sciences

Education should provide each learner with knowledge and understanding of mathematics and the sciences, encouraging exploration and discovery as well as the acquisition of facts.

Every student should have knowledge and understanding of mathematics and the sciences, with an appreciation of their practical applications as well as theoretical aspects.

Besides substantive knowledge, each student should derive from the study of mathematics and the sciences an understanding of process, ranging from methods of problem-solving to the scientific approach to inquiry and investigation. These subjects should be presented in a way that encourages exploration, experimentation and critical thinking, so as to hone the intellectual skills of every student.

Goal 9: Capacity and Desire for Lifelong Learning

Education should foster and stimulate the natural desire for lifelong learning, and should help learners develop the skills necessary to reach personal goals.

Learning is a lifelong necessity if individuals are to cope successfully with our complex, diverse, and ever-changing society. Learning should be appreciated by everyone as an opportunity for enrichment and growth throughout a lifetime, both for the acquisition of new skills on a continuing basis, and for the sense of achievement and happiness that comes from using one's time and abilities as creatively as possible.

Education must, therefore, help all students develop a framework for seeking and receiving new information, stimulate the desire to learn, and encourage continuous learning.

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ACKNOWLEDGMENTS

The Massachusetts Educational Assessment Program would not have been possible in its present form without the generous support of many individuals and school districts throughout the state. Since its inception in 1985, five Curriculum Advisory Committees have worked to develop the assessment framework, to review the test items, to interpret the results, and to give guidance and support to the entire effort.

We wish to pay special tribute to these committee members who contributed so much to this process. We are also grateful to the school districts that supported their efforts by granting released time during the school year. The efforts of the one, the support of the other, has resulted in an assessment program that not only reflects the values and academic aspirations of Massachusetts educators, but the most profound thinking in each of the content areas.

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EXECUTIVE SUMMARY

This report on the the second Massachusetts Educational Assessment Program, authorized under Chapter 188, is based on tests administered in April 1988 to all fourth, eighth and twelfth grade students. It also summarizes information obtained through questionnaires administered to these students, their teachers and principals. Unlike the 1986 report, which discussed the level of achievement in each subject tested, this report focuses on general themes that are reflected in all the areas tested. It also describes students' opportunities to learn in schools throughout the state and identifies those school factors that are associated with high school achievement.

In 1988 the subject areas tested were reading, mathematics, science and social studies. The frameworks which form the basis for these tests were developed by curriculum committees in each area. The relative emphasis placed upon topics within each subject area was determined by a curriculum survey sent to all schools throughout the state. Because of the wide area of skills and knowledge covered, there are over 3000 test items in the entire assessment. Questions from the National Assessment of Educational Progress (NAEP) are included in the test in order to establish national comparisons. Additional items come from other sources or are newly developed. Each student takes only one portion of the entire test, and results are aggregated at the school and district level.

The tests are not designed to measure the achievement level of a particular grade, but everything a student could be expected to learn up to that grade. Similarly, they are not designed to measure a specific curriculum, but the body of knowledge and kinds of thinking that content experts believe essential to the subject area tested. More generally, they reflect the Goals for Education in Massachusetts, which have been endorsed by the Massachusetts Board of Education.

Students. Some 52,216 students in grade four, 52,794 students in grade eight, and 57,272 students in grade twelve completed the assessment and its accompanying questionnaires. Chapter Two discusses their responses in regard to the assessment areas.

The attitude of fourth grade students toward learning was very positive. Ninety-five percent say their teacher expects them to do well "always" or "most of the time." Almost 60 percent report that they enjoy going to school with the same frequency. Over 85 percent believe that they are a good or very good readers. Forty-three percent responded that they enjoy their social studies classes. Over 50 percent regarded science as their favorite or one of their favorite subjects; almost 70 percent regarded math in the same way. Sixty-five percent reported that they have 30 or more books at home and almost half report reading for pleasure "almost every day." All of these variables were related to achievement.

Attitudes of eighth graders were mixed. Forty-three percent stated that they had perfect school attendance for the last 4 weeks. Less than 30 percent report reading for pleasure "almost every day" and 20 percent said that they "never or hardly ever" read on their own time. Twenty-four percent reported that they looked forward to their social studies class "most of the time"; a similar percentage replied "hardly ever." Thirty-six percent regarded math as very helpful in getting along in everyday life; 26 percent felt similarly about science and and 29 percent about social studies. On the other hand, 60 percent of the students agreed that social studies consisted mainly of memorization.

Attitudes at the twelfth grade level tended to be more negative in regard to schooling. For example, only 22 percent of students reported perfect school attendance. When asked about the time spent reading for pleasure, almost a third reported that they spent less than an hour a week and 25 percent stated that they "never or hardly ever" read on their own time. Only 22 percent believed that math was very useful in everyday life or doing practical jobs, while 12 percent and 13 percent regarded science and social studies in this light. Again, mathematics was looked upon as more useful academically. While slightly fewer twelfth graders think of math and science as mainly memorization (between 40 percent and 45 percent), the same percentage of twelfth graders as eighth graders (60 percent) thought of social studies as memorizing.

A quarter of eighth graders stated that they were very interested in science. Their scores were 170 points above the 21 percent who were not at all interested. At the twelfth grade level, a smaller proportion

of students (20 percent) were interested in science, while 32 percent were not at all interested. In the case of these students, the score differential rose to 300 points.

Achievement. In Chapter Three, an informational model is proposed for the interpretation of assessment results. It reflects a set of common concerns that cut across the subject areas. Although the ability to think clearly and critically may be dependent upon the context in which it occurs, students' difficulties are not limited to one context. Prominent among the findings were:

1. **Students at all levels have the capacity to do higher order thinking; however, they do not routinely use that capacity.** This appears to reflect a general reluctance to engage in the thinking process. Their responses to some questions reveal their tendency to avoid extended thinking, favoring shallow answers or answers that can be found quickly through strategies that can be applied without thinking. In reading, students prefer responses that are taken verbatim from the reading passage. In math, they prefer to mechanically apply a computational algorithm when simple reasoning would be more successful. In science and social studies, they appear to be quick to select an answer without first asking, "Is this something I can figure out?"

2. **Many students appear to be searching for simple ideas or connections when the task requires them to develop broad concepts or to evaluate information.** Knowledge alone does not guarantee success on tasks that require something to be done with that knowledge. Students seem unable to organize their knowledge in the service of understanding.

3. **Students lack important tools for making connections among ideas or understanding broader, underlying concepts. Included among these tools are the appropriate vocabulary which will allow for precision of definition, analytic and evaluative skills, and those procedural skills in reading and problem solving which permit a selection of strategies.**

School Resources and Practices. When, as in Chapter Four, results are viewed in terms of school practices, it becomes apparent that certain school characteristics are related to performance. Among these are:

1. **The availability and use of resources.** The effect of the availability of resources is particularly apparent at all grade levels. Schools which have scientific resources, computers, calculators, classroom libraries and laboratories scored higher than those that did not, regardless of the extent of use. Nevertheless, the frequency with which some resources were used was positively related to achievement.

2. **Instructional activities that promote active involvement.** In the early grades, time on task *per se* is not sufficient for high achievement in schools. It must be accompanied by a varied and active instructional program that relies upon such activities as using mathematical manipulatives, collecting data, and sharing papers. In the later grades, the assignment of papers, the use of research in social studies, the "doing of science" are all features of high performing schools.

3. **Instructional availability.** By contrasting features of the curriculum within and among schools, it was apparent that, for many schools, "thinking skills" are considered suitable only for those students who are considered proficient in their "basic skills." Basic skills, in their turn, are conceived almost exclusively as low-level skills, such as computation, symbol decoding and basic knowledge. It is often forgotten that reasoning is also a basic skill. Courses such as mathematics, where students are grouped by ability, highlight these curricular differences that are associated with the increasing achievement differences among students.

Conclusions. Despite the strong influence of home and personal factors on students' school performance, the role of the school cannot be ignored. The assessment results have shown that the curriculum itself, including instructional content and practices, is strongly related to student achievement. Cognitive research has demonstrated the role that active involvement and experience play in the learning process. These assessment results confirm these findings and suggest ways that schools might improve their curriculum and instruction.

CHAPTER 1: BACKGROUND TO THE MASSACHUSETTS EDUCATIONAL ASSESSMENT PROGRAM

The Massachusetts Educational Assessment Program (MEAP) is one of two statewide testing programs mandated by Chapter 188 of the Acts of 1985. The purpose of the assessment program is twofold: to furnish information to improve curriculum and instruction in Massachusetts schools, and to provide reliable results for comparisons at the school, district, and state levels. It does not produce scores for individual students. The Massachusetts Basic Skills Testing Program, the second program created by Chapter 188, is designed to identify individual students who may need assistance in mastering basic skills in reading, writing, and mathematics.

Under the mandates of Chapter 188, the Massachusetts Educational Assessment Program tests all students at three grade levels in major subject areas biennially. Massachusetts students in grades 3, 7, and 11 participated in the first round of MEAP testing in April 1986; they were assessed in reading, mathematics, and science. School, district, and state results were released the following November.

The second statewide assessment was administered to students in grades 4, 8, and 12 in April of 1988; the subjects assessed were reading, mathematics, science, and social studies. Over 162,000 Massachusetts students completed the tests, as the chart below illustrates.

	Grade 4		Grade 8		Grade 12	
	No.	%	No.	%	No.	%
Students enrolled	57,991	100	58,907	100	62,169	100
Students completing the tests	52,216	90	52,794	90	57,272	92
Bilingual students completing the tests	938	2	600	1	1,026	2
Special education students completing the tests	4,842	8	4,020	7	2,503	4
Students excluded from the tests	5,158	9	4,866	8	2,681	4

The only students excluded from the MEAP tests were those exempt as special education or bilingual students, and those who were absent from school during testing and make-up sessions.

The selection of grade levels, test administration times, and subjects is guided by the mandate of Chapter 188 that the performance of Massachusetts students be compared to that of their peers nationally. The change in grade levels between the first and second MEAP administrations, and the addition of social studies, were undertaken to conform to the plans of the National Assessment of Educational Progress (NAEP). Test questions from the National Assessment are used as part of the MEAP tests and provide the basis for national comparisons. Other questions are developed specifically for the Massachusetts tests to assess further specific objectives or to measure Massachusetts objectives not included as part of NAEP's testing.

The goal of the assessment—to provide school and district results, rather than scores for individual students—guides test development, administration, and reporting decisions.

Test Development

Test questions cover a broad range of student knowledge and abilities, from basic to higher order skills, in all the subjects assessed. The tests measure not what is taught in any particular grade, but everything a student could be expected to learn up to that grade level, encompassing the entire range of student ability and providing a challenge for all students.

Test objectives are first reviewed by district and school personnel in Massachusetts when the original MEAP tests are developed, and are revised and updated for each round of testing. After the objectives are set, curriculum area committees (see Appendix) review hundreds of test items for each grade level and select those they believe are most appropriate for use in the Massachusetts program. These items come from previous MEAP tests, from NAEP tests, and from questions developed and field tested specifically for Massachusetts students. An equity concerns committee reviews the tests to ensure that they are fair and relevant to students from all ethnic, racial and cultural backgrounds.

In addition to the multiple-choice questions traditionally used in educational assessments, the 1988 MEAP tests included several open-ended (short answer) questions in each subject, designed to examine students' ability to apply knowledge and understanding in different contexts. Approximately five percent of the students completed an open-ended section of the test. In the spring of 1989, as another part of the MEAP program, a sample of students across Massachusetts will participate in performance testing in science and mathematics.

In addition to the subject area tests, all students, teachers and principals at the appropriate grade levels complete questionnaires about their backgrounds, classroom practices, attitudes toward learning, and other factors that have been shown to relate to educational achievement. Highlights from the questionnaire responses are included in chapters 2 and 4 of this report.

Test Administration

The MEAP tests are given in individual classrooms by local test administrators—classroom teachers, in most cases. To insure uniform testing procedures, school personnel attend test administration workshops and are provided with manuals giving specific directions for all components of the testing program.

Because individual student scores are not reported as part of the Massachusetts assessment, test administration is accomplished through a technique known as "matrix sampling."

The assessment tests are comprehensive, covering a broad range of objectives in each subject. If individual student scores were the goal of the program, each student would be required to complete several hundred test questions so that the scope of his or her knowledge and abilities could be validly assessed. Testing time for each student in this situation would total between twelve and twenty hours. Because the program seeks only aggregate school and district scores, however, each student completed only a sample of test questions in each subject, reducing testing time to 90 minutes per student. The total number of test questions in each subject area was divided into several forms per grade; each student completed one form. In any school or district, many students were tested using the same form, thereby producing valid and reliable test scores for the school and district as a whole. The total number of test questions, by grade and subject, is shown below.

	Number of Test Questions		
Content Area	Grade 4	Grade 8	Grade 12
Reading	151	201	251
Mathematics	230	294	389
Science	230	262	371
Social Studies	240	279	390
Total	851	1036	1401

Test Administration at Grade 4. All fourth grade students completed a practice test, student questionnaire, and the four-session cognitive test. The practice test was designed to acquaint young students with the kinds of questions and procedures used in the test so that they would be comfortable and able to perform to their ability in actual test sessions. Students recorded their answers on a machine-scannable answer sheet.

Each of the four test sessions covered one subject—reading, mathematics, science or social studies. At grade 4, there were twelve different forms of the test booklet with subjects arranged in different orders, so that students in one classroom worked at different subjects during any one test session. For purposes of comparability, the items used in the NAEP tests and included in the Massachusetts tests were presented at the beginning of Session 1. In addition to the multiple-choice questions, approximately 8 percent of the fourth grade students answered several open-ended or short-answer questions in each subject during Session 4.

Test Administration at Grades 8 and 12. The upper level students in the MEAP testing program completed two student questionnaires (one common to all students, and one of several forms matrix-sampled among students) and the two-session cognitive test.

The test administration procedures for grades 8 and 12 were similar to those at grade 4. At grade 8, there were sixteen different forms of the test, and at grade 12, there were twenty different forms. NAEP items were presented at the beginning of either session. Approximately five percent of the students in these two grades completed open-ended questions in each of the four subjects during the second test session. A statewide sample of student responses to these open-ended questions will be read and evaluated, and special reports on this part of the MEAP program will be issued during the 1988-89 school year.

Teacher and Principal Questionnaires. All fourth grade teachers completed one form of a teacher questionnaire exploring teachers' background and training, school practices and decision-making, and classroom activities. Eighth and twelfth grade teachers of language arts, mathematics, science and social studies completed individual forms of the teacher questionnaire which contained, in addition to the more general material, questions directed toward the subject they teach. Fourth grade teachers and eighth grade teachers of mathematics, science and social studies were also given sample questions from the tests and asked whether the knowledge or skill needed to answer the question was part of their curriculum and, if so, at what level.

Principals of schools with fourth, eighth, and twelfth grade students answered questions measuring schoolwide variables affecting education: experience and longevity of the teaching staff, curriculum development activities in the school and district, school programs in reading and writing, and problems facing their schools.

A summary of responses to the student, teacher and principal questionnaires is included in Chapter Two of this report, "Students, Teachers, Principals and Their Schools—A Description."

Reporting of Results

Data from the Massachusetts Educational Assessment Program will be released in a variety of ways during the 1988-89 school year. School and district reports, issued early in November, provide detailed information on student performance. They include scores for each subject, broken down by subskills and objectives, presented in relation to a Comparison Score Band which allows schools and districts to compare their scores to others with similar background characteristics; student score distributions; questionnaire responses related to performance on the MEAP tests; and other information. *Using the School Report*, delivered with school and district reports, explains how to use MEAP data to examine curriculum and facilitate curriculum development.

As noted above, a series of reports concerning student performance in open-ended sections of the assessment tests will be released during the coming year. A report comparing the performance of Massachusetts students to national results will be provided when data are released by the National Assessment of Educational Progress.

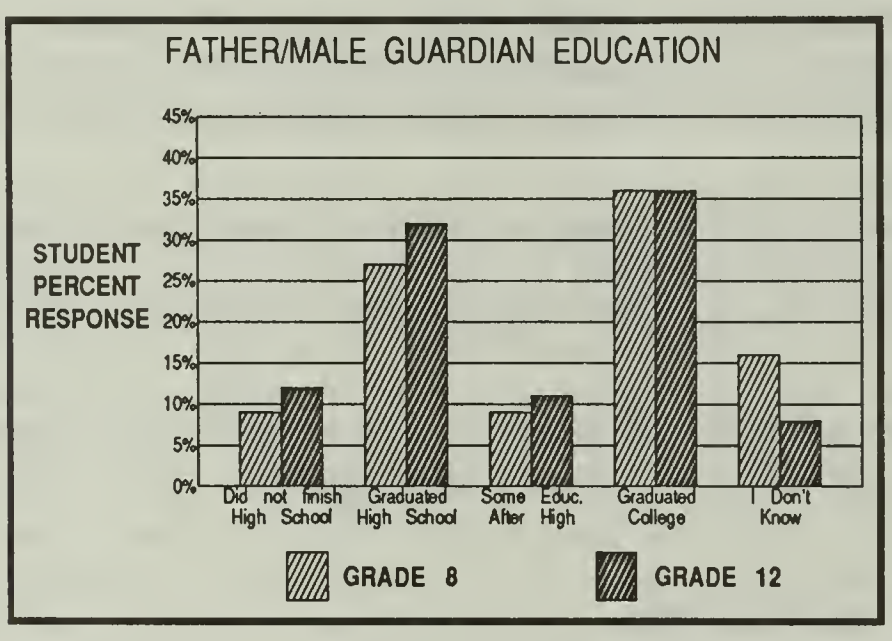
CHAPTER 2: STUDENTS, TEACHERS, PRINCIPALS, AND THEIR SCHOOLS — A DESCRIPTION

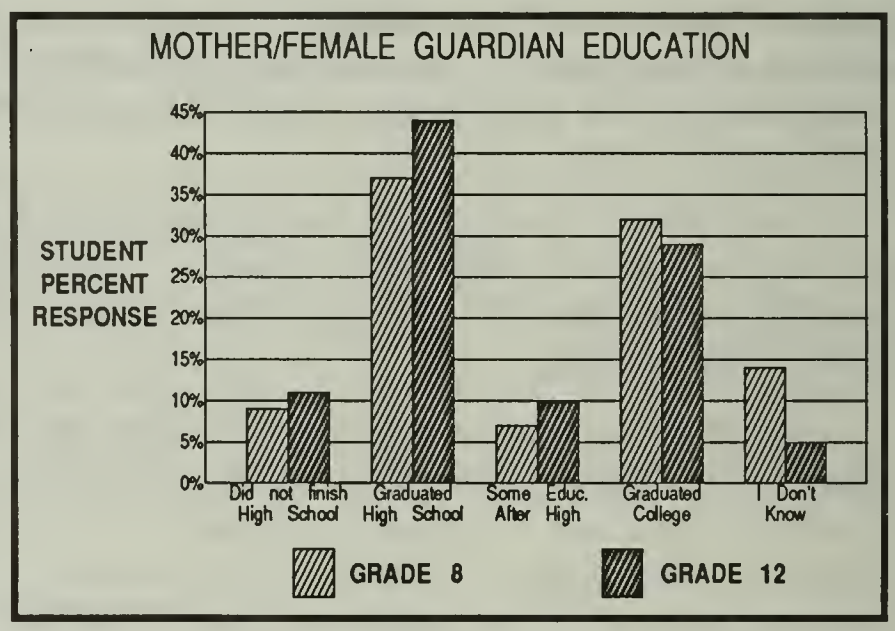
Student Questionnaires

All students who participated in the Massachusetts Educational Assessment provided some information about their backgrounds, attitudes toward learning, and activities both inside and outside the classroom by means of the student questionnaires. At grade 4, all students responded to a common questionnaire composed of 22 items; the material was read aloud to students, and teachers could assist in clarifying questions or answer choices if the students requested such help. At grades 8 and 12, students independently completed one common questionnaire for each grade level, and several different forms of a second questionnaire, totaling approximately 40 questions. Each form of the questionnaire focused on a different subject tested in the assessment—reading, mathematics, science, or social studies. Data from the student questionnaires give some insight into student attitudes and factors that affect learning.

Data Used to Compute Comparison Score Bands. Several background questions asked in the questionnaires were used for interpretation of results and other analysis, particularly the construction of the Comparison Score Bands used in the school and district reports of results.

A question about parental education ("the highest level of school attended") was asked at grades 8 and 12. Patterns of response at both grades were similar.





Another factor used in the computation of Comparison Score Bands at grades 8 and 12 was the incidence of languages other than English spoken in the student's home. This question was also asked at grade 4, although it did not contribute to calculations for the band. Results from that question show that English is the predominant language in students' homes; nearly 90 percent of the students report that foreign languages are "never" or "sometimes" spoken in their home.

A third factor examined in comparative scores for elementary students (but asked of students at all grades) was book ownership. Students were asked how many books of their own, excluding school books or comic books, they have at home. Interestingly, 65 percent of the fourth graders report that they have thirty books or more; only half of the grade 8 students and slightly more than one third of the grade 12 students report that they own that many books.

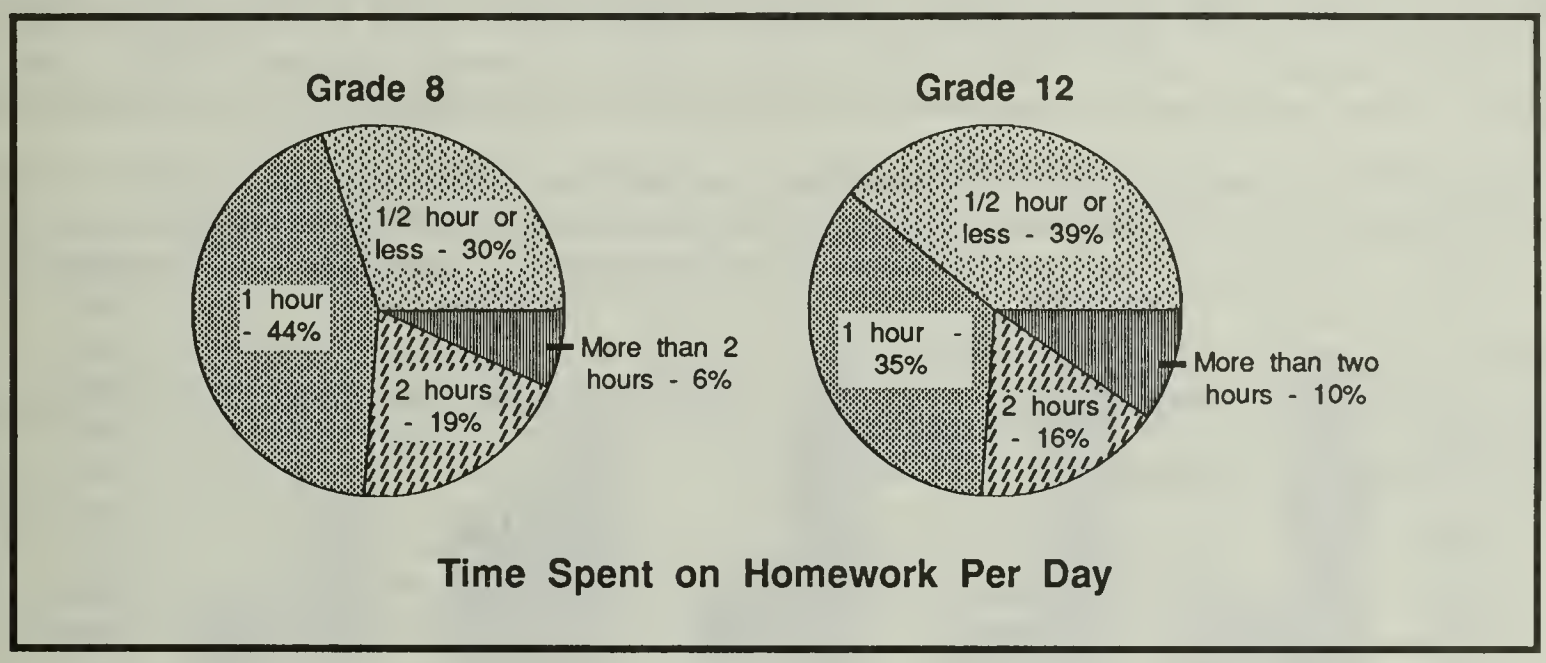
Other questionnaire items asked of fourth graders and used in the Comparison Score Bands were length of residence in the U.S. and attendance at a preschool program. The percentage of students receiving free and reduced price lunches in the school and the Kind of Community were used at all grade levels; they were determined by means other than the student questionnaires.

Activity Outside the School. Students at all grade levels were asked about activities they pursue on their own time, focusing on three primary pursuits—time spent reading for pleasure, doing homework, and watching television. In addition, high school students were asked about time devoted to paying jobs and family responsibilities.

Almost half of Massachusetts' fourth graders read for pleasure "almost every day." That figure drops to 29 percent for eighth graders and 25 percent for twelfth graders. At the opposite end of the spectrum, some 10 percent of the elementary students, 20 percent of the junior high students, and 25 percent of the high school students surveyed report that they "never or hardly ever" read on their own time.

Grade 12 students were also asked how much time they spend each week reading for fun. Almost a third of these high school seniors report that they spend less than an hour a week; another 20 percent estimate they read for about one hour. As might be expected, students who read frequently and for longer periods of time show significantly higher scores in reading on the Massachusetts assessment; at fourth grade, for example, students who read "almost every day" had scores that were over 60 points higher than students who read "once or twice a week," and over 150 points higher than those who "never or hardly ever" read on their own.

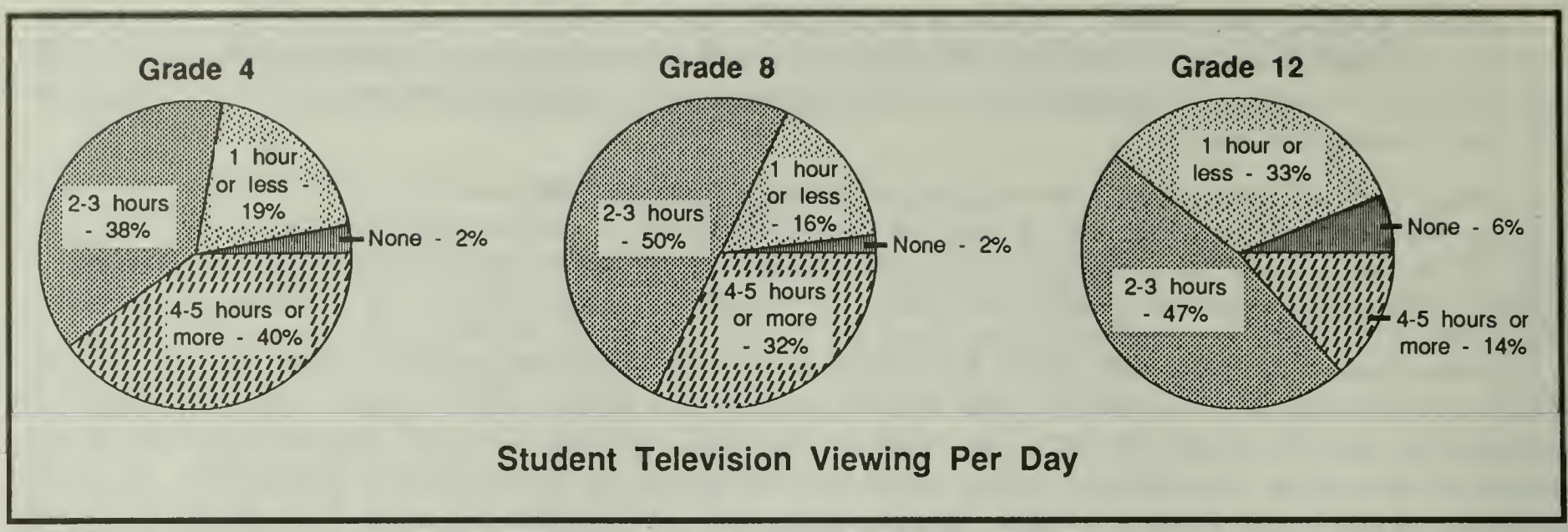
At all grades, students were asked how much time they spend on homework each day. The majority of students at grade 4 estimate they spend between one half (47 percent) and one hour (43 percent) on homework each day. The amount of time spent doing homework by eighth and twelfth graders is similar, as the chart below illustrates.


Grade 8
1/2 hour or less - 30%
1 hour - 44%
More than 2 hours - 6%
2 hours - 19%
Grade 12
1/2 hour or less - 39%
1 hour - 35%
More than two hours - 10%
2 hours - 16%

Time Spent on Homework Per Day

At the upper two grades queried, time spent on homework and assessment scores show a direct relationship: students who spend increasing amounts of time on homework did significantly better on the MEAP tests in all subjects. That relationship did not generally hold true for fourth graders, however: scores for students who report spending more than one hour per day on homework are lower than those for students who spend less time. It may be likely that those students are working longer but less effectively than their classmates.

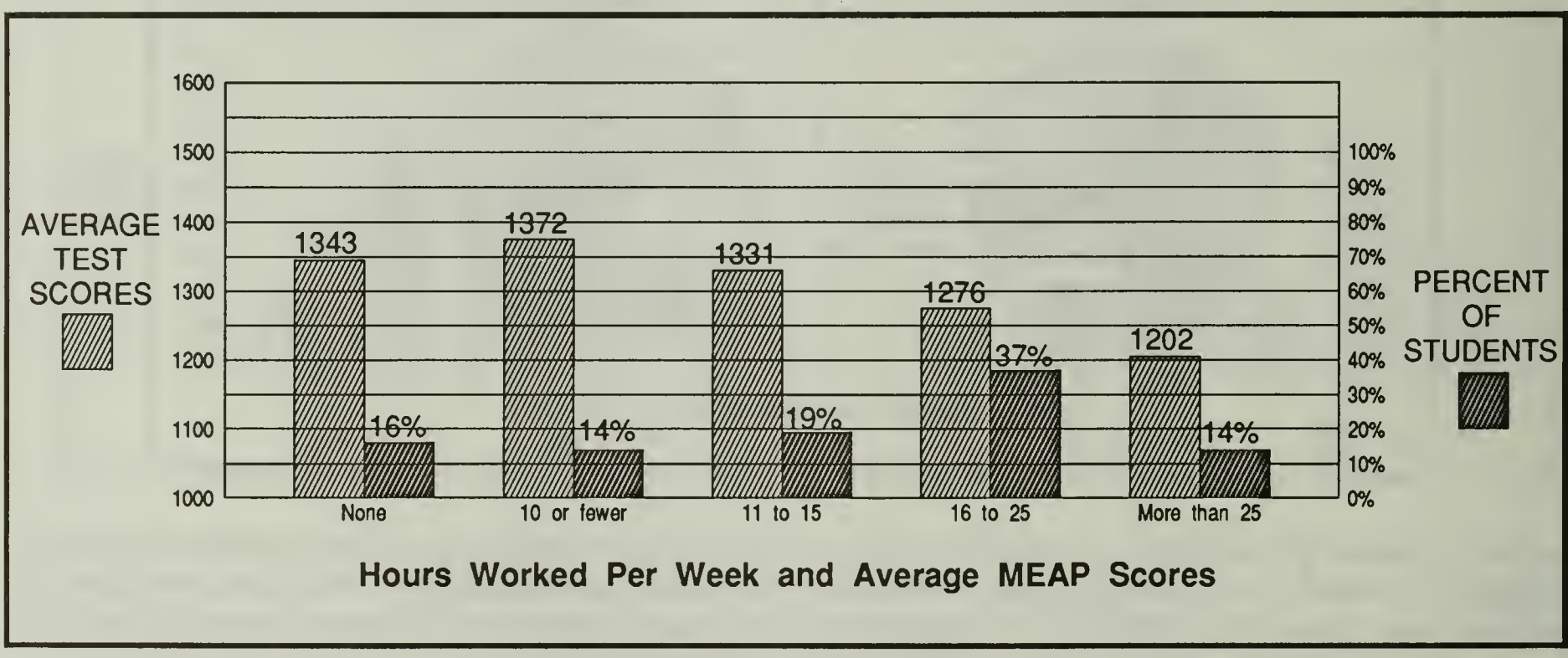
Television viewing offers strong competition to more academic pursuits in filling students' free time. As shown by the charts below, the great majority of students spend more than two hours a day with video entertainment.


Grade 4
1 hour or less - 19%
2-3 hours - 38%
None - 2%
4-5 hours or more - 40%
Grade 8
1 hour or less - 16%
2-3 hours - 50%
None - 2%
4-5 hours or more - 32%
Grade 12
1 hour or less - 33%
None - 6%
2-3 hours - 47%
4-5 hours or more - 14%

Student Television Viewing Per Day

Moderate amounts of television viewing—even up to two to three hours per day—seem to have little impact on test scores. Watching television for more than that, however, is associated with significantly lower achievement.

Grade 12 students were also asked about the amount of time each week devoted to family responsibilities and work outside the home. The demands on students in these two areas are significant. Over half report that they work more than 16 hours per week at a paying job; their MEAP scores in all subjects are significantly lower than those of their peers. The graph below shows the extent of that relationship.

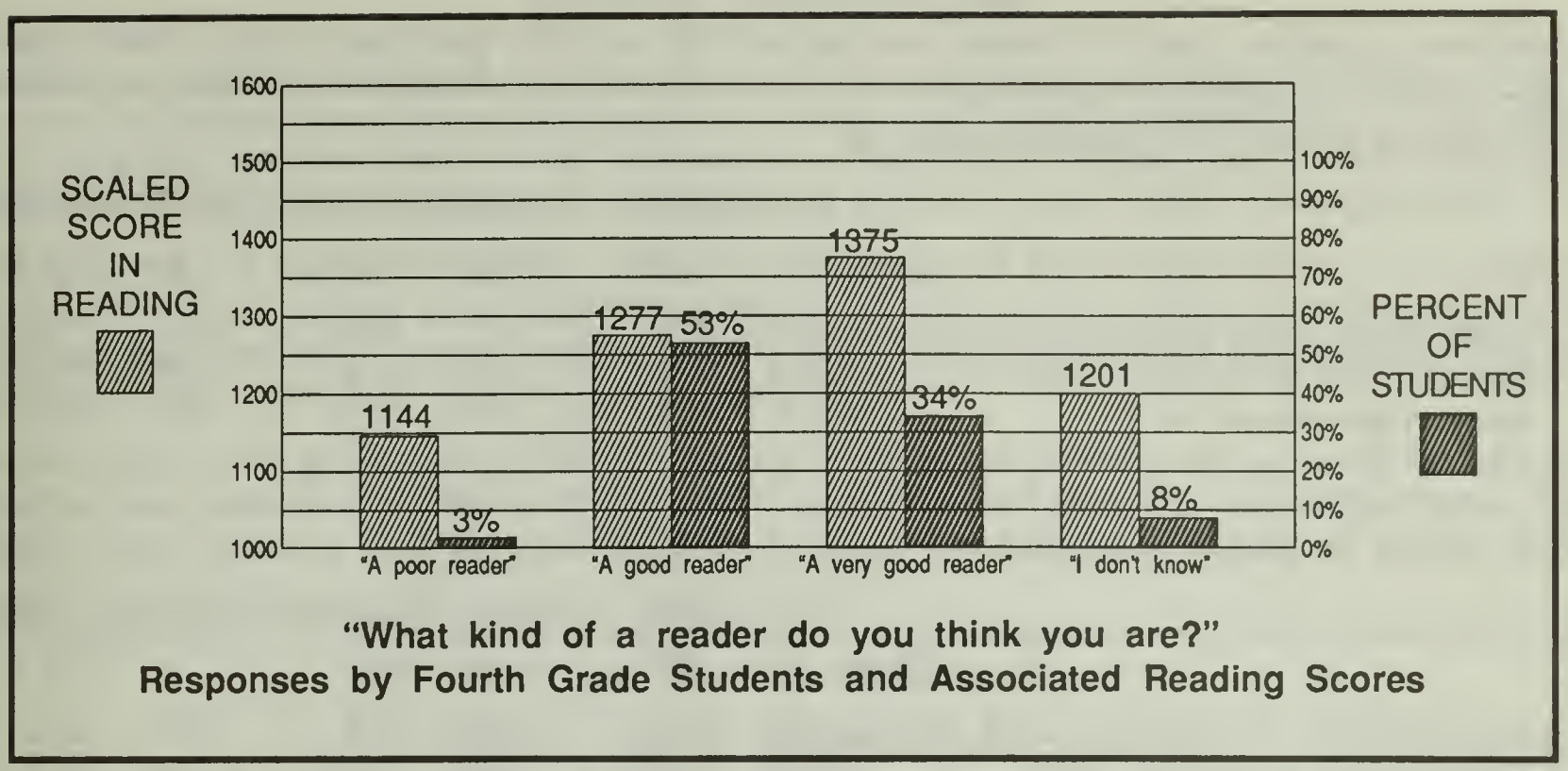


Hours Worked Per Week and Average MEAP Scores

The relationship between assessment scores and family responsibilities is not significant, although some 42 percent of the students surveyed devote more than six hours per week to jobs in the home, another demand on their time.

Attitudes toward School and Learning. Students in all grades were asked a variety of questions about their feelings toward school, their own achievement, school programs, and their attitudes about learning.

Fourth graders report positive feelings about their school experience. Ninety-five percent of them say their teacher expects them to do well "always" or "most of the time"; almost 60 percent report that they enjoy going to school with the same frequency. When asked to judge their reading abilities, students responded this way:



"What kind of a reader do you think you are?"
Responses by Fourth Grade Students and Associated Reading Scores

At grade 12, two factors are strongly correlated with above-average scores in all subjects assessed in the MEAP program. Students who report that they are in a college preparatory program score 250 points higher in all tests than their peers; their scores reach 1400 and above, as compared to the state average of 1300, while their classmates generally achieve scores from 1100 to 1200. Students' future aspirations also show a direct link to achievement.

Students at all grades were asked a variety of questions about their attitudes toward specific subjects. Fourth graders were asked primarily about how much they enjoyed the different subjects covered in the MEAP assessment; their responses are shown below.

How do you feel about science/mathematics compared to other subjects you study in school?

	Science	Mathematics
It is my favorite.	16%	36%
It is one of my favorites.	38%	32%
There are others I like better.	34%	18%
It is my least favorite	12%	13%

How often do you enjoy social studies class?

Always	18%
Most of the time	25%
Sometimes	37%
Never or hardly ever	19%

The questions at grades 8 and 12 delved more specifically into the perceived utility of the subject.

How useful do you find social studies in . . .

	Very Useful		Somewhat Useful		Not Very Useful	
Grade	8	12	8	12	8	12
understanding the world around you	39%	29%	49%	53%	11%	17%
getting along in everyday life	29%	41%	41%	41%	29%	45%
doing other course work	17%	15%	51%	52%	31%	31%

How useful do you find science in . . .

	Very Useful		Somewhat Useful		Not Very Useful	
Grade	8	12	8	12	8	12
understanding the world around you	46%	30%	49%	47%	12%	21%
getting along in everyday life	26%	12%	46%	45%	27%	41%
doing other course work	20%	15%	48%	47%	31%	36%

How useful do you find mathematics in . . .

	Very Useful		Somewhat Useful		Not Very Useful	
Grade	8	12	8	12	8	12
understanding the world around you	20%	14%	51%	40%	29%	45%
getting along in everyday life	38%	NA	45%	NA	16%	NA
doing other course work	36%	27%	50%	49%	14%	23%
doing practical jobs	NA	22%	NA	41%	NA	36%

The high percentages of students who question the value of their coursework in these subjects in "getting along in everyday life" and in "understanding the world" around them is disturbing, particularly at the twelfth grade. For almost one third of these students—those who do not plan to further their education—this coursework will be the extent of their training related to exercising the responsibilities of citizenship in an increasingly technological society.

The patterns of response to one final question asked of students in all three grades are interesting. Students were asked how often they talk about school work with someone in their family. Their responses are as follows:

	Percent of students at		
	Grade 4	Grade 8	Grade 12
Almost every day	59	56	39
One-two times per week	24	22	27
One-two times per month	5	6	9
Never or hardly ever	12	16	25

More information about student attitudes and activities in school, particularly as related to responses to teacher and principal questionnaires, is reported and analyzed in Chapter 4: Opportunities to Learn.

Teacher Questionnaires

Teachers of fourth, eighth and twelfth grade students completed a questionnaire asking about their professional backgrounds and experience and their classroom and school responsibilities. All fourth grade teachers completed the same form of the questionnaire; eighth and twelfth grade teachers responded to different forms according to subject area—mathematics, science, social studies, or language arts.

Characteristics of the Teaching Force. Eighty-one percent of all fourth grade teachers in Massachusetts are female; 73 percent earned their bachelor's degree in education. The teaching force at this grade level is stable and experienced: 50 percent of the teachers have taught between ten and twenty years, and 32 percent have spent more than twenty years in the classroom.

At the upper two grades surveyed, the teaching force is less homogeneous: teachers' educational backgrounds are more diverse and tend to be concentrated more heavily in their subject areas than in education. The following table summarizes their characteristics and backgrounds.

Massachusetts Teachers at Grade 8 and 12

		Language Arts		Mathematics		Science		Social Studies	
	Grade:	8	12	8	12	8	12	8	12
Gender:	Male	29	42	47	56	63	69	66	74
	Female	70	58	52	43	36	30	33	25
Degree:	education	27	12	30	14	23	11	20	11
	subject area*	52	74	46	67	57	77	70	81
Taught:	10-20 yrs	55	53	53	50	47	45	46	44
	20+ yrs	24	34	27	34	30	39	39	45

*"subject area" means that the individual's degree is in the subject currently taught

The degree listed in the chart above refers to the bachelor's degree. A significant percentage of Massachusetts teachers hold masters' degrees or higher—49 percent at grade 4; approximately 60 percent of teachers in all subjects at grade 8; and close to 75 percent of the teachers at grade 12. Of the fourth and eighth grade teachers who hold advanced degrees, most are in education; at twelfth grade, advanced degrees are almost evenly divided between education and the subject taught.

Teachers were also asked about time available for professional development activities, and how often they participate in such activities. The first question asked about "released time beyond that required by district-wide agreements" for conferences, workshops, and other professional activities: uniformly between 30 and 40 percent of Massachusetts teachers report that there is no such time available to them; another 30 to 40 percent say they receive from two to four days each year. When asked about voluntary professional development activities pursued during the past school year, most teachers (from 30 to 40 percent) say they have taken part in two to four workshops or meetings. Between 20 and 35 percent of Massachusetts teachers report that they have participated in no voluntary professional development activities during the past year.

Grade 4. Elementary teachers responded to several questions which provide information about processes and activities regularly pursued in fourth grade classrooms across Massachusetts.

Reading instruction appears to be the teachers' primary activity in grade 4, although—based on responses to the 1986 MEAP questionnaires from grade 3 teachers—the amount of time devoted to reading instruction decreases between the two grades. In the 1986 questionnaires, 87 percent of the third grade teachers reported they spend five hours per week on reading instruction; 52 percent of the fourth grade teachers in 1988 reported comparable figures. The chart below shows the number of hours of instructional

time per week devoted to the subjects assessed in the MEAP tests at grade 4, and the percentages of teachers selecting those options.

Subject	0-1 hours	1-2 hours	2-3 hours	3-5 hours	5+ hours
Reading	1%	2%	3%	42%	52%
Mathematics	1%	1%	5%	77%	14%
Science	9%	34%	39%	16%	1%
Social Studies	4%	24%	46%	23%	1%

The lack of attention to science instruction shown in the chart above reflects teachers' own educational backgrounds. When asked about post-secondary courses in science and science teaching, between one quarter and one third of the elementary teachers replied that they had taken no courses in those fields; 86 percent of them, however, are responsible for teaching science in their fourth grade classes.

Chapter 4 of this report, titled "Opportunities to Learn," further discusses classroom practices and other background factors as they relate to achievement on the MEAP tests.

Grades 8 and 12. Middle and high school teachers spend many hours at school-related activities outside the classroom. In general, teachers devote the largest amounts of their time away from teaching in planning and preparing for classes, correcting papers and keeping records, and general supervising of students. Approximately one third of the middle and secondary teachers spend between two and four hours weekly at these tasks, and another third devote four to eight hours per week to them. Forty to sixty percent of these teachers spend one hour or less per week in meetings with other teachers for lesson planning, curriculum development, guidance counseling, etc. or in coaching or advising extracurricular activities.

Principal Questionnaires

All principals of schools housing fourth, eighth, or twelfth grade students were asked to complete a questionnaire addressing school policy and practices. The questionnaires reveal how diverse factors affect the schools, and provide background, context, or contrast to information gleaned from student and teacher questionnaires.

The majority of school principals in Massachusetts are male—70 percent at the elementary level, 84 percent in the junior high/middle schools, and 88 percent in the high schools. Slightly more than one third of the principals at all levels have served in that capacity for ten to twenty years; approximately another quarter of the principals have been at their posts for five to nine years.

Principals were also asked about released time provided to teachers for professional development activities. While teachers were asked about the number of days of released time made available to them, principals were asked to indicate the percentage of teachers who were granted such leave. Their responses are as follows:

Percentage of Teachers Granted Released Time for Professional Development Activities

Percentage of Teachers Granted Released Time	Principals' Responses at Grade 4	Grade 8	Grade 12
0-10%	26	16	7
11-25%	20	27	25
26-50%	18	22	24
51-75%	10	13	15
76-100%	25	22	27

Schoolwide Programs and Curricula. Principals were able to report on their policies of involving parents in their children's education. Generally, nine out of ten principals report that parents are notified if their child is absent from school for 2-3 days. The same figure applies to mid-semester notices about poor grades in the elementary and middle schools; that practice is followed in only 3 percent of the state's high schools. Parent-teacher conferences are held at least once a semester in 64 percent of the elementary schools, 51 percent of the middle schools, and 42 percent of the high schools in Massachusetts.

Almost 90 percent of the elementary and middle school principals indicated that they have a written curriculum in all subjects assessed as part of the Massachusetts testing program—reading, mathematics, science and social studies.

Problems Encountered in Massachusetts Schools. Principals at all grade levels were presented with a list of potential schoolwide problems and asked to indicate whether each was "serious," "moderate," "minor," or "not a problem" in their school. For this report, the percentage of principals who chose "serious" or "moderate" has been aggregated; that figure is shown below, along with the percentage of principals who indicate that the behavior is "not a problem" in their school.

Behavior Problems Facing Massachusetts Schools

	Percentage of Principals Selecting					
	Serious or Moderate			Not a Problem		
Grade:	4	8	12	4	8	12
Student tardiness	12	24	59	47	25	6
Student absenteeism	14	20	45	43	34	12
Student cutting of classes	0	2	23	97	71	28
Physical conflicts among students	9	13	9	43	36	41
Robbery or theft	2	4	9	80	53	33
Vandalism of school property	6	8	13	58	39	23
Student use of alcohol	0	7	40	98	59	12
Student use of illicit drugs	0	6	29	97	58	11
Student possession of weapons	0	4	3	96	78	74
Physical abuse of teachers	0	2	0	97	84	79
Verbal abuse of teachers	3	11	10	75	47	35

Data from the student, teacher and principal questionnaires gives insight into what is happening in Massachusetts schools—and also into what these various groups of people think is happening. The two are not always necessarily identical; congruences and discrepancies are each useful, in their own ways, for identifying strengths and weaknesses, opening discussion, and planning for the future. In addition, both the school-related and non-school-related variables identified by students, teachers and principals have significant correlation with performance on the MEAP tests; these correlations are discussed in Chapter 4.

CHAPTER 3: THE ASSESSMENT OF THINKING

This chapter explains how thinking skills are addressed by the Massachusetts Educational Assessment Program and summarizes patterns of results on test questions measuring them. The discussions of results here pertain primarily to multiple-choice questions. While multiple-choice formats can accomplish a great deal in the measurement of thinking, free-response questions can provide information on students' thinking skills beyond that gained from multiple choice. Free-response questions were administered to a statewide sample of students as part of the MEAP program. Separate reports on the results of that component of the assessment will be produced and distributed by the Massachusetts Department of Education.

Thinking and School Programs

The increasing recognition of a school's responsibility for developing students' thinking abilities is having a profound effect on curriculum development and testing. Experts in cognitive psychology and other fields are refining their definitions of various domains of thinking and applying them in the development of curricular materials and measurement instruments. In every major school subject, thinking skills are listed as goals in themselves in scope-and-sequence documents, curriculum guides, etc. Educators are reexamining their disciplines, giving special consideration to the thought processes involved in their specialty areas.

Perhaps the most important result of this attention to thinking is in perceptions of achievement or "expertise" within different school disciplines. The ability to store information, in and of itself, is no longer considered as important as the ability to store and use information. With this shift in emphasis comes also a shift in focus from content to what the students do with that content — a shift in interest from information to information processing.

This interest in thinking skills is not a recent development. For years, descriptions of content domains have included them — as process skills in social studies, inquiry skills in science, reading comprehension skills, and mathematical skills. While there is still some merit to maintaining many aspects of these traditional conceptualizations of process skills, the problems associated with them should be avoided. For example, in science and social studies, the continuing debate over the relative importance of "content vs. process" has led to the overemphasis of one or the other in many programs. Focusing on either in isolation is probably a mistake. In reading and mathematics, skills-mastery approaches to instruction are now seen as having serious limitations in terms of how well they prepare students to function in "real" situations requiring competence in reading and mathematics.

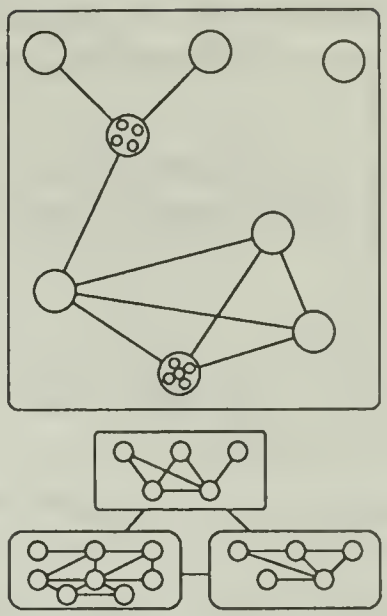
What Test Questions Measure

In developing the MEAP tests, multidimensional frameworks were used to map the domains to be covered. These frameworks were generally content-by-process matrices. The content dimensions included categories like "Life Science" in science, "Economics" in social studies, or "Geometry" in mathematics, along with several subcategories within each. The process categories included cognitive processes or levels capturing various types of thinking that test questions might require. In science and social studies, for example, variations of Bloom's Taxonomy of Cognitive Objectives were used to identify items addressing recall, comprehension, application, and higher order thinking skills.

Both the content and process categories are useful for describing the test content so that resulting scores in the different categories can be used to identify strengths and weaknesses in instructional programs. (See *The 1987 Massachusetts Educational Assessment Program: Description of Test Content and Reporting Categories*, available from the Massachusetts Department of Education.) However, in reporting on statewide performance across the content areas with a "thinking perspective," a different framework for interpreting results might be useful, especially considering the common concerns raised by the content area specialists who examined statewide test results in their subject areas question by question. An information model is described below. It illustrates how ideas might be linked in the minds of students and is designed

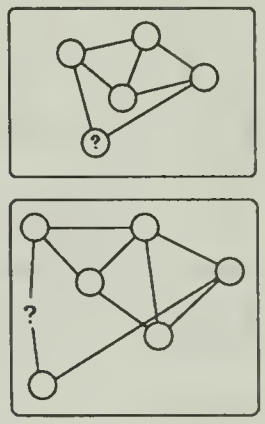
to help synthesize results in the different areas. It should not be considered a model for cognition should it bear any similarities to such a model.

The model is mainly a collection of ideas with many interconnections and subclusters of ideas. Thinking of an idea as being much like an atom, it is reasonable to regard an idea as itself being a cluster of smaller pieces. For example, the idea that nutrition is important to one's health links the concepts of nutrition, health, and importance. Those ideas could be broken down further, perhaps to the language decoding level. For our purposes, ideas can be either broad or specific.

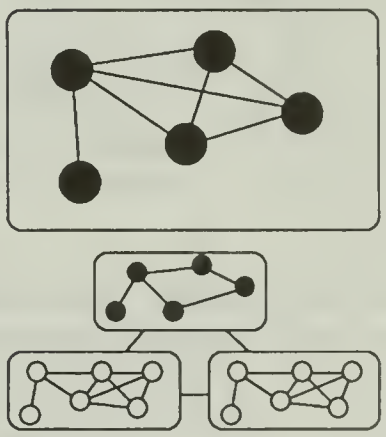


Clusters of ideas are interconnected. For example, the law of conservation of energy (a cluster) and different kinds and forms of energy (kinetic, potential, heat, mechanical, etc. — another cluster) can be linked to each other and to the notion of engine efficiency, which, in combination, they help to explain.

Some test questions are intended to find out if a specific idea exists at all within a student's information structure. Though we sometimes speak of specific facts (ideas) in isolation, they are always linked to some other ideas; such linkages are necessary to enable retrieval of information. Most test questions are intended to see if particular linkages already exist (e.g., What causes day and night? Most students already know what "day" and "night" mean and that the earth rotates on its axis.) or to provide new ideas and require the student to link them to "old" or to other "new" ideas (e.g., questions requiring students to infer the causal relationship between two elements in a reading passage).



Some ideas pertain to procedures — e.g., process skills in social studies, computational or problem-solving skills in mathematics. These ideas include general rules that can be applied to specific situations. Clusters of procedural ideas could include steps in a computational algorithm or problem-solving strategy, along with conditions necessary for the algorithm or strategy to be applicable. Sometimes a link is maintained between a set of procedural ideas and a particular situation (e.g., a math problem) previously encountered. Seeing the similarity between the new and old problem situations might be what enables the linking of the procedures to the new problem.



MEAP Statewide Results

In preparing a report on "thinking" results across the four subject areas assessed by MEAP, decisions about what themes to highlight in different sections proved quite difficult. There were, of course, observations by the members of the different advisory committees that were similar. For example, most of them felt that students generally had difficulties seeing or making connections among ideas — e.g., seeing commonalities and differences, identifying parallel situations or themes. However, the discussion in the previous section suggests that all test questions address the interconnections among ideas. What is most important in searching through the test results is finding evidence of the kinds of situations in which students have difficulty or are successful and clues to the possible reasons for their difficulty or success.

Another matter of interest to interpreters of results is the information students have at their command before answering a question — prior knowledge. While many points can be made regarding the role of prior knowledge, the discussion of the information model in the previous section suggests that prior

knowledge underlies all test item results. We generally are testing either students' prior knowledge or how students incorporate new information into their existing knowledge bases. This is nothing new. Even Jean Piaget's early work describes learning as the assimilation of new information into existing structures or schemas and the changing of such structures (accommodation) when the new information conflicts with the old.

The remainder of this chapter presents assessment findings from each of the four subject areas that support three general points concerning the thinking performance of students.

I. STUDENTS AT ALL LEVELS HAVE THE CAPACITY FOR HIGHER ORDER THINKING. THEY TEND TO USE HIGHER ORDER THINKING SKILLS APPROPRIATELY IN SOME SITUATIONS, BUT NOT IN OTHERS.

Students at all ages use higher order thinking skills daily when making decisions about which brand of a product to buy, how to divide chores, what rules are unfair and how they might be changed. However, assessment results suggest that, for whatever reason, such skills are sometimes not used. While it may be reasonable to find specific questions in which students fail to apply good thinking, it appears that there are broader contexts in which students do not use their thinking skills. The problem seems to exist in content areas (science and social studies) as well as skill areas (reading and mathematics). In content areas, it may come from viewing areas (or subareas) as bodies of knowledge rather than modes of inquiry. One who regards history as a collection of facts, for example, may avoid higher order thinking on test questions requiring more than simple recall. In skill areas, the problem may come from a traditional perception of the areas as consisting of isolated, low-level, trainable abilities requiring little or no understanding to employ. The folly of overemphasizing skill mastery in reading and mathematics is well supported by research evidence; however, it is apparent from MEAP results that many students, and perhaps teachers, have the traditional view of these areas.

Social Studies. A major reporting category in social studies (Clarifying, Evaluating and Using Information) included test questions that required little, if any, content knowledge, but rather focused on critical thinking skills. The success of many grade 4 students on some of these questions lends support for the first general finding about students having the skills. Based on the less satisfactory performance of the older students, however, it seems that students' capacity to think may be stifled as they progress through the grades.

The assessment results show positive signs regarding fourth graders' analytic skills. Two-thirds to three-fourths of these students succeeded on some challenging questions requiring them to distinguish between facts and opinions. After reading a conversation between a football coach and a reporter, over 60 percent of the fourth grade students identified an assumption made by the coach. The same approximate number recognized the other person the reporter should interview to get a balanced view.

At grade 8, most students can distinguish fact from opinion; however, their analytic skills in identifying assumptions, arguments in support of a government action, and logical inconsistencies are weak. Generally, grade 12 students were considerably more successful than eighth graders on the critical thinking questions, but not nearly as successful as one might hope. The two test questions below exemplify these findings.

Which of the following is an argument for the federal government's allowing states to raise the maximum speed limit to 65 mph?

% of Students Gr 8	% of Students Gr 12		
49	28	A.	Research has shown that higher speeds are associated with more frequent accidents.
32	56	*B.	Truckers are paid by the hour, so higher speeds reduce shipping costs and therefore help the economy.
10	10	C.	There is evidence that at higher speeds more fuel is wasted.
8	4	D.	The world's fossil fuel supply is limited.

Assumptions are beliefs that are frequently unstated and taken for granted. Conclusions and decisions to do things are often based on assumptions.

When a person passes out fliers describing a political candidate's views to shoppers at a mall, the person's behavior assumes

% of Students Gr 8	% of Students Gr 12		
24	17	A.	the fliers are interesting.
28	24	B.	the candidate will win the election.
32	50	*C.	the shoppers can read.
12	10	D.	the mall produces satisfied customers.

Questions dealing with reasons, arguments, assumptions, etc. are not new to testing. Yet the results on these are particularly poor. When questions addressing similar skills appear on some tests (e.g., basic skills, mastery), they are sometimes overly simplistic, with answer options consisting of one true statement and three false statements. Identifying the true statement results in success on such a question no matter what the question actually asks; answering correctly gives little assurance that the student has the skill intended to be measured. All four options in the first question above are true. It is disappointing, however, that so few students answered correctly since options A, C, and D are clearly arguments against raising the speed limit. The large number of students selecting A may have gone no further than the first option since it is true. Identifying arguments for and against propositions is an important critical thinking skill, and the truth of the arguments is not at issue in many instances.

Identifying assumptions is also a traditionally tested skill, and again one which has often been treated simplistically. As the second question above suggests, the making of an assumption narrows down the choices a person has to consider when making a decision or drawing a conclusion. The results suggest that this function of an assumption is probably not understood very well.

The inability of students to apply, synthesize, or evaluate historical information will be discussed later in this chapter. This weakness was apparent at all grade levels. In economics, however, grade 4 students showed good reasoning skills even though their understanding of many economic concepts may be lacking. Three-quarters of them reasoned that toys would cost less after Christmas because fewer people want to buy them. The same number figured out that the best way to earn money by helping a neighbor would be to offer to do something the neighbor does not have time to do. These results suggest that the situation in economics may be different from that in history. The students apparently recognized the necessity of reasoning out the answers on the economics questions, whereas, in history, students seem to feel questions are asking for something they either know or do not know rather than expecting them to think something through.

Science. Eighth and twelfth graders had difficulty with questions involving the nature of statistical inference and causal inference. Only 30 percent of the eighth graders and 48 percent of the twelfth graders realize that when one collects information from a sample, one assumes the results would have been the same had the entire population been used. Results on the two questions shown below suggest that many students are willing to jump to inappropriate conclusions or deductions when there is the potential for "common causes."

Because a factory dumps chemical wastes in a river in an area where there is a high incidence of cancer, the local citizens claim that the chemicals are causing the cancer. What are they assuming?

% of Students Gr 8	% of Students Gr 12		
32	30	A.	The chemicals are reacting with other materials in the water forming a poison.
26	20	B.	Chemicals should not be dumped into rivers or streams.
36	46	*C.	There is nothing else in the area that could be causing the cancer.
5	3	D.	Cancer is a dreaded disease killing many people.

An airport was built at the edge of a large city, despite the protests of those living in the neighborhood. They complained that the noise level would be hazardous to their health. During the first year of the airport's operation, the incidence of partial hearing loss in the region directly adjoining the airport rose 10 percent over that in the preceding year. Which of the following is a valid conslusion based on these data?

% of Students Gr 8		
39	A.	The protesters were correct. The increased noise had a harmful effect on the population.
8	B.	The increased hearing loss was not significant.
40	*C.	There may be a correlation between the noise and the increased hearing loss. Further study is appropriate.
13	D.	There is no proof that the noise caused the hearing loss and therefore nothing can be done.

The results on the first question above could also be seen as consistent with findings pertaining to assumptions discussed previously in the social studies section. Many students apparently do not understand the connection between assumptions and what follows (a decision or conclusion). Again students were easily distracted by reasonable statements (a hypothesis in A and a socially desirable view in B) neither of which is the assumption that, when made, necessitates the conclusion about the cause of cancer.

Only 36 percent of the eighth graders and 40 percent of the twelfth graders recognized the type of evidence that would be the strongest evidence of a link between smoking and cancer—direct observation

of cigarette pollutants changing body cells, as opposed to various examples of correlational evidence. Thus, many students rated indirect evidence as more reliable than what their own eyes tell them. Clearly, students' understanding of what constitutes good and poor evidence is deficient.

Reading. The major emphasis of the reading instruments was on inferential comprehension, which was broken down further into categories with a critical thinking orientation. Test questions were considered to have either an "internal" or "external" perspective relative to text. Questions in the "internal" category address mostly traditional reading comprehension skills —analyzing the text and evaluating meanings. The "external" category includes skills of comprehension monitoring which deal with information about the text used by a reader in managing the reading experience — analyzing the type and characteristics of text and evaluating alternative strategies for reading. (For a more in-depth discussion of the reading framework, see the pamphlet *Reading and Thinking: A New Framework for Comprehension*, distributed by the Department of Education.)

A reading test is much like the sections of a science or social studies test dealing with inquiry or process skills. Information is provided to the student, and the student must use that information, along with critical thinking skills and prior knowledge reasonably expected of most students. Interestingly, reading results show that students avoid drawing inferences or evaluating evidence. Many select answers to "high inference" questions that suggest the students expect answers to appear in the text. To these students, the text, like the area of history to some, must be a body of knowledge to be stored rather than used. This is consistent with a dated approach to reading; the current view of reading treats it as an interactive process involving the reader in "thinking with text." Reading results discussed in later sections support the notion that many students fail to recognize the need for thinking when reading.

Mathematics. The most important single conclusion to be drawn from careful examination of the MEAP findings is that students appear to approach mathematics as manipulation of numbers — following mechanical procedures with minimal thought. Sometimes students can succeed at mathematical tasks without understanding the concepts involved. In other situations, however, even those students who have adequate conceptual knowledge to reason out an answer tend not to make use of that knowledge and, as a result, frequently fail. The remainder of this section describes findings supporting these statements.

Seventy-four percent of the fourth grade students successfully identified 3/4 as the fractional part of a figure that was shaded. However, given a circle with half shaded one way and one-quarter shaded another way and asked to use the diagram to compute 1/2 + 1/4, only 32 percent could succeed. Over half of the students gave the common incorrect answer of 2/6 resulting from adding numerator to numerator and denominator to denominator. Students should be able to "compute" with even more complex fractions mentally long before they are introduced to the computational algorithms for fractions. (Only three-fourths of the eighth graders selected the correct response to "1/2 + 1/4 = ?")

The results below suggest that students are able to reason out the answer successfully; yet when the fraction is provided in numeric form, a different kind of reasoning takes place and the success rate is almost halved. Most likely, when the numeric form was used, more students decided to follow computational algorithm rather than think further about the task.

An oil tank is $\frac{1}{2}$ full. If 125 gallons are added to the tank, it will be full. How many gallons are in the tank when it is full?

% of Students Gr 4	% of Students Gr 8	
11	9	A. 62 $\frac{1}{2}$ gallons
47	19	B. 125 $\frac{1}{2}$ gallons
9	4	C. 128 gallons
33	67	*D. 250 gallons

An oil tank is half-full. If 125 gallons are added to the tank, it will be full. How many gallons are in the tank when it is full?

% of Students Gr 4	
6	A. 62 $\frac{1}{2}$ gallons
27	B. 125 $\frac{1}{2}$ gallons
7	C. 128 gallons
60	*D. 250 gallons

Another set of findings (involving numbers versus models) shows a similar pattern. Generally, better than four-fifths of the students across the grades could find the next term in a number sequence when a constant is added to or multiplied by each term to determine the next term (a form of inductive reasoning).

One of these questions was paralleled by a sequence question involving diagrams instead of numbers, each diagram consisting of three sticks more than the previous diagram. Students had much more difficulty with this question. As we have seen earlier in this section and will discuss again in a later section, students tend not to use models when they would be helpful in mathematics. The sequence task results above further reveals students' difficulty with models and seeing the association between the models and numbers.

Only half of the eighth graders and three-quarters of the twelfth graders could select the correct answer to "40 is what percent of 80?" This question does not require computation; it is conceptual. Many more students than succeeded on the task must know that half is 50 percent of something.

Given a drawing of a picture frame with the lengths of a side and the bottom shown, only 33 percent of the fourth graders could tell how much framing material had to be bought to build the frame. Many students just operated on the two numbers given — half of the students gave the semiperimeter.

Look at the results on the problem below.

Right now, Bob has $9 in the bank and Carol has $23 in the bank. From now on, each will save $1.00 every week. How much money will Bob have saved when he has half as much as Carol?

% of Students Gr 8	% of Students Gr 12		
21	17	A.	$11.50
22	32	*B.	$14.00
8	5	C.	$15.00
5	2	D.	$46.00
43	43	E.	Bob will never have half as much as Carol.

Almost half of the students appeared to believe their task was to simply perform a computation using two numbers given in the problem. One-half of $23 is $11.50, which will never be reached since an even $1 is saved each week!

II. IN RESPONDING TO TEST QUESTIONS, MANY STUDENTS APPEAR TO BE SEARCHING FOR SIMPLE IDEAS OR CONNECTIONS EVEN WHEN THE QUESTIONS CALL FOR THE STUDENT TO DEVELOP BIGGER IDEAS OR CONNECTIONS OR EVALUATE INFORMATION. AS A RESULT, HAVING ALL THE PREREQUISITE KNOWLEDGE OR "PIECES" DOES NOT GUARANTEE SUCCESS ON TASKS REQUIRING SOMETHING TO BE DONE WITH THE PIECES.

Social Studies. The evaluative skills of students at grade 4 were generally weaker than their analytic skills. Fewer students than expected (just over half) identified the best clue that a story took place in the past. Fewer than half recognized the object in the story that was not evidence that the story took place in the past. The students had difficulty recognizing causes and effects, although the cause-and-effect questions were more difficult than ones usually posed when students first encounter the concept. Instead of simple, physical events, the questions involved social events, and some required the students to infer the **most likely** cause or effect. One of the more difficult questions is shown below.

A city closed down a neighborhool playground. Which of the following is the MOST LIKELY EFFECT of this?

% of Students Gr 4		
6	A.	The city opened up a public swimming pool.
15	B.	More families moved into the neighborhood.
55	C.	The city ran out of money to take care of the playground.
24	*D.	More children played in streets and on the sidewalks.

The evaluative skills of both eighth and twelfth graders were generally disappointing. Given short passages (journal entries, speech excerpts, etc.), students performed poorly on questions requiring them to evaluate evidence and arguments. In an excerpt from a speech by Al Smith, a former Democratic candidate for president, just over a third of the eighth graders and about half of the twelfth graders could identify the claim best supported with facts. Just over half of the students at both grade levels could identify

the best support for another claim in the speech. And finally, only 32 percent and 42 percent of the eighth and twelfth graders respectively could interpret the meaning of the "[loud noises]..." that occurred during the speech. This question required that students first recognize evidence throughout the transcript of the speech that the listeners were strong supporters of Smith (e.g., "[applause]" at particular points). Then they had to take that into consideration along with the statements immediately preceding the loud noises to best interpret the loud noises themselves. This question illustrates the hierarchical nature of thinking skills — evaluation questions require careful analysis before evaluation.

Grade 4 students know many facts in history, but have difficulty pulling them together. They have probably been exposed to the idea that sailing ships existed in ancient times, and should certainly associate such vessels with early explorers such as Magellan or Columbus. Yet only a third of them identified the sailing ship as the oldest form of transportation, as opposed to the steamboat, automobile, or railroad train. It could be argued that by grade 4, students have not developed a strong sense of time and, therefore, should have difficulty on such a question. However, others argue that more must be done in the younger grades to develop this sense, at first perhaps in terms of "when you were little," "when your parents were kids," and "long before your grandparents were alive." Nevertheless, the failure to reason out the answers to questions such as these remains a problem in the higher grades. Only two-thirds of the eighth graders could identify the event (founding of Jamestown) that occurred first in a sequence of events. (The other events pertained to the Declaration of Independence, the Constitution, and the Civil War.) Clearly, grade 8 students have had enough exposure to these events to reason out their order.

At all levels, students seem to be lacking many of the broader concepts underlying many facts they know. At grade 12, only about half of the students identified mercantilism and religious dissent as the greatest impetus for establishing the colonies in America. The same number could identify common causes for the American, French, and Russian revolutions. Students generally know about the U.S. system of checks and balances; yet only 13 percent and 31 percent of the eighth and twelfth graders respectively recognized the Senate's action on the Robert Bork nomination (described in the question) as an application of checks and balances rather than judicial review, the power of veto, and minority dissent. Almost all fourth graders know that U.S. citizens have the right to speak freely or say what they think. Yet only 40 percent knew that a citizen speaking out against a new law is using freedom of speech. More students felt that the citizen would be arrested.

Test questions involving graphic display of information produced the usual results — students can generally read data directly from graphs and charts, but they have difficulty interpreting the information. The graphs and charts encountered in magazines and newspapers are frequently more complex than those appearing on many tests. MEAP used some questions that included complex displays that students would realistically encounter. For example, grade 12 students were given a bar graph showing the percentages and numbers of immigrants coming from different countries between 1820 and 1975, and another graph showing the corresponding information for the year 1975. Only a third of the seniors could determine that the graphs showed a decrease in the percentage of immigrants coming from European countries.

Science. The evaluation of designs of investigations is not exclusively a formal scientific activity. Determining whether information yields certain conclusions is an important general skill. Logic analysis should reveal when conclusions are inappropriate because critical variables are not controlled, and such judgments do not require knowledge of formal scientific terms such as "variables" and "control."

Grade 4 students were relatively proficient at determining what information is needed to answer certain research questions and at recognizing what is being studied, given the description of an investigation. They were somewhat weaker at selecting the best design for an investigation. Only 35 percent of the fourth graders chose the best design for an experiment on the effectiveness of a new plant food. Half of the students felt that it would be best to measure the growth of a particular plant, then begin feeding it the new food, and then measure the growth again. At grade 8, 86 percent of the students identified what was being studied in an investigation, and 85 percent knew how to improve a simple experiment by controlling a variable that was not originally controlled. At grade 12, results were mixed on test items involving experimental controls (40-80 percent correct). Many of the investigations presented were complex, involving large numbers of variables requiring control. Given pictures of materials to select from in

conducting an experiment, only 37 percent of the twelfth graders determined that two strings and two bobs would be needed in an experiment to determine the effect of string length and weight of bob on the swing of a pendulum.

Frequently, tests reported to measure data organization skills merely provide graphic or tabular information and ask students to translate the information or draw conclusions from it. An important step is often skipped. The Massachusetts assessment included questions asking students about how to process raw data. One question, used at all three grade levels, asked students to select the table that could be used to show the relationship between two variables—sex of students and club membership. The question provided a table of raw data which, for each case or student, gave information on sex (male or female), age, and club membership (yes or no). Not surprisingly, only a third of the fourth graders picked the correct response — a cross tabulation of sex and club membership. Many simply picked a table of raw data with the irrelevant variable (age) excluded. Sixty percent of the eighth graders and 73 percent of the twelfth graders selected the appropriate table. On another question, approximately half of the fourth graders knew to use male and female average height to determine if girls in the school tended to be taller than boys (as opposed to focusing on the height of the tallest males and tallest females). On a variation of this problem, only 59 percent of the eighth graders were successful.

At all grade levels, science questions involving graphs and tables produced the usual results—students have little difficulty in reading directlyfrom graphs and tables, but drawing conclusions or inferences from the data proved to be somewhat more difficult. On several questions, one-half to two-thirds of the fourth graders recognized the extent to which they could generalize from information. Sixty-four percent of the fourth graders knew that one piece of wood sinking in water meant that they could conclude only that "some woods sink." Fifty-seven percent of the fourth graders (and 67 percent of the eighth graders) knew that, based on the finding that a liquid has five properties of water, one could only conclude that the liquid is "probably water." Given a bar graph depicting average number of heartbeats per minute for four different exercises, 60 percent of the fourth graders correctly concluded that "running causes the heart to beat faster." Those choosing the other options either failed to acknowledge the dependent variable or they made an inappropriate inference; 29 percent claimed that "running is the best exercise."

The failure of students to apply their knowledge is evidenced in the life science data. Eighty percent of the fourth graders could identify a legitimate food chain, and 89 percent knew or identified the effect if a link were eliminated in a simple chain. However, on a question describing a grass—rabbit—hawk chain, only 52 percent of the eighth graders realized that a disease killing off the rabbits would mean that the grass would grow taller and fewer hawks would live in the area. Only 53 percent of the twelfth graders were successful on a parallel question. While just over half of the eighth and twelfth graders correctly identified all the needs of photosynthesis, better than 90 percent picked options that included light. Yet only 45 percent of the eighth and 62 percent of the twelfth graders related the need for light to the fact that algae grow near the surface of water. Only 43 percent of the eighth graders connected the need for light to plants having larger leaves on a forest floor. Only 56 percent of the eighth graders and 66 percent of the twelfth graders knew that the bottoms of cut stalks of grass are yellow because of the lack of light.

The failure to apply good reasoning skills is revealed in results on questions in evolution and ecology. Students generally know that offspring inherit traits of parents. Correct responses to questions about evolution explained how giraffes with longer necks survived when food was scarce and passed their traits on to offspring, and explained how mosquitoes immune to insecticides passed this trait on as well. Only approximately 40 percent of the eighth and just over 60 percent of the twelfth graders could pick these responses as reasons for giraffes' longer necks and increasing numbers of immune mosquitoes. Only 38 percent of the fourth graders identified "draining a swamp" as being more harmful to animal and plant life than cutting down a tree, killing a mouse, or building a fence. Just over two-thirds of the eighth graders identified radio broadcasts as being least upsetting to ecological balance in an area when compared to burning a forest, draining a swamp, or constructing a dam.

In astronomy, students have good low-level knowledge of relative motions of bodies in space. For example, 84 percent of the fourth graders know that the earth revolves around the sun. However, only

29 percent of these students can associate the spinning of the earth on its axis with the fact that it is morning on one side of the earth while it is evening on the other. A similar problem exists at the upper grades. Only 36 percent of the eighth graders associate phases of the moon with its revolution around the earth. Only 45 percent of the eighth graders and 47 percent of the twelfth graders associate sunrise and sunset with the earth's rotation

In geology, 78 percent of the eighth graders and 84 percent of the twelfth graders knew the role of earthquakes and volcanoes in the formation of mountains. Yet only 30 percent of the eighth graders and 38 percent of the twelfth graders could explain how fish fossils could appear in mountain rocks. Almost half of the students at both grade levels claimed that a great flood took the fish to the mountain tops.

In the physical sciences, it is not surprising that grade 4 students have difficulty with questions on conservation of matter. However, at the upper two grade levels, these consistently present unwarranted problems. Just under half of the eighth and twelfth graders realize that dissolving a pound of salt in twenty pounds of water will result in twenty-one pounds of salt water. Just half of the eighth graders and two-thirds of the twelfth graders realize that the weight of a quantity of water before and after freezing would be the same.

A simply stated question included in the assessment is, "Water is (a) an element, (b) a compound, (c) a solution, (d) a mixture." Only 38 percent of the eighth graders and 48 percent of the twelfth graders responded correctly. This question reveals more than its simplicity might suggest. Few students would be likely to answer this based on their having memorized lists of elements, compounds, etc. Most students would be able to identify water as H_2O, a combination of hydrogen and oxygen. It is disappointing that more students cannot translate this knowledge to a higher success rate on the question.

Reading. Traditional fact/opinion questions have not always been associated with reading passages. Frequently they have simply asked the student to identify one of four isolated statements as either a fact or an opinion. Such questions can result in "mastery" of a superficial form of a far more complex skill. Critical thinking experts criticize such questions for representing an overly simplistic distinction of facts and opinions. Good reading material that students might encounter outside of testing offers many opportunities for asking a full range of fact/opinion questions and doing so in the broader, more realistic context of a story or content piece. Furthermore, it is very often vital that the reader make the appropriate distinctions to understand the material. A variety of MEAP fact/opinion questions is provided below.

[Passage: Story of a space rescue mission]

Which of the following statements is NOT a fact?

% of Students Gr 4		
14	A.	Luke and Ann had been without food for days.
17	B.	Corporal Marino hid some extra food on the ship.
24	C.	"Now they have a little more time to make repairs."
45	*D.	"We can get them back to Earth for sure."

[Passage: Biographical sketch of Amelia Earhart]

Which of the following is a statement of opinion?

% of Students Gr 8		
6	A.	Amelia Earhart was the first person to fly solo from Hawaii to the mainland.
82	*B.	Amelia Earhart was the bravest pioneer of flight.
6	C.	In 1937, Amelia Earhart vanished somewhere in the Pacific.
6	D.	Amelia Earhart wanted to make a round-the-world flight.

[Passage: Page from social studies text summarizing events during revolution]

Which of the following statements from the passage is **not** an opinion?

% of Students Gr 8	Gr 12		
13	5	A.	The turning point of the war was the American victory at Saratoga in 1777.
57	72	*B.	On July 4, 1776, the Declaration of Independence — written by Thomas Jefferson — was adopted.
12	8	C.	The victory of the Americans and their French allies at Yorktown assured American independence.
17	15	D.	The Revolution is the single most important event in United States history.

[Passage: Supreme Court decision in McCulloch vs. Maryland]

Which of the following paragraphs in the passage is primarily factual?

% of Students Gr 12		
27	A.	paragraph 1
47	*B.	paragraph 2
17	C.	paragraph 4
6	D.	paragraph 5

The grade 4 question is a challenging one. While the negative wording can be problematic for some students, there is evidence that such items "work"; also, the concept of "not" is important for children to understand. The third and "best" distractor included the adjective "little," and sometimes the presence or absence of such words is the sole basis for students' answers. The grade 8 question about Amelia Earhart reflects the simplistic fact/opinion distinction by providing four statements, one of which, the opinion, contains a superlative adjective. Students handle this type of question well. However, grade 8 students had considerably more difficulty with the question from a social studies text. Fewer than half of the twelfth graders succeeded on the question about the Supreme Court decision. Paragraph 2 in the passage was almost entirely statements about what the Constitution includes.

Identifying causes and effects is a "skill" that falls in three different reporting categories in the Massachusetts assessment. If the cause and effect are stated and linked in the text, then questions about them are most likely categorized as "literal comprehension." When the cause and the effect both appear in the text, but the reader must infer the relationship, corresponding questions would fall in the "internal analysis" category. When the cause itself or the effect itself must be inferred, these inferences would fall in the "internal evaluation" category; the questions often ask for what is "most likely." The three levels of cause-and-effect questions reflect increasing levels of difficulty, with the greater inferential leaps required for the third type. A few people are critical of the "what is most likely ..." questions, feeling that if a "wrong" answer has any possibility of truth, then the question has more than one correct response. However, there are best and most likely answers. The good answers are clearly defensible based on strength of evidence within the passages. It is important that students be challenged to draw these kinds of inferences as well as lower level inferences.

Questions in the Massachusetts assessment requiring students to weigh evidence in such a manner ("What is the strongest evidence of . . . ", "What conclusion is best supported by the evidence. . .") result in fairly low performance. Apparently, students tend, in their reading, not to be risk takers — not to be willing to reason and draw their own inferences. They prefer to take what the writer has said at face value. Such a disposition worked adequately for students on traditional reading tests that did not require the reader to be an active participant in the reading process. However, current theories of reading and improved practices in testing acknowledge that the mental activity of the reader is as important as the material to be read in fostering comprehension. The apparently challenging questions shown below required the students to use evidence provided in the text to make inferences.

[Passage: Content piece on types, parts, and health of teeth]

In the box labeled, "Tooth Dissection," why does the author tell you to wrap your tooth in a cloth?

% of Students Gr 4	
15	A. to save the tooth for the tooth fairy
2	B. to throw the tooth away
29	C. to keep the tooth from breaking
54	*D. to hold the pieces when the tooth breaks

[Passage: Article on the expanding domain of a species of killer bees]

What was the **most** disturbing discovery made by the scientists who investigated the Lost Hills colony of African bees?

% of Students Gr 8	Gr 12	
37	31	A. a 5 1/2 ft. x 1 ft. nesting area
11	9	B. twenty honeycombs
15	9	C. thousands of dead bees
37	51	*D. three abandoned queen bee cells

[Passage: Three visitors' views of the working conditions in the Lowell mills in the early 1800s]

Which of the following conclusions is **best** supported by evidence in these three views of Lowell?

% of Students Gr 12	
26	A. The girls were underpaid.
24	B. The girls hurried to work in the morning because they liked their jobs.
4	C. The girls were unhealthy.
45	*D. The girls worked in noisy, poorly ventilated rooms.

The grade 4 question pertains to an "inset" activity in the passage that explained how to break a tooth into pieces with a hammer to see the inside parts. The passage did not give a reason for first wrapping the tooth. The large percentage of students who selected distractors A, B, and C apparently picked answers they thought might be good reasons for wrapping a tooth totally disregarding the passage and the purpose

of the activity. The poor performance at grades 8 and 12 on the "killer bees" question suggests that many students missed an essential idea in the passage — the concern about the bees surviving and moving on to a new location to which the correct response directly relates. The grade 12 question about the Lowell mills had half of the students selecting conclusions with no supporting evidence and, in fact, having evidence to the contrary.

A particular concern of advisors reviewing the reading assessment results at all three levels is the poor performance of Massachusetts students on questions about important ideas — themes, main ideas, etc. The results depicted below illustrate this problem.

[Passage: *Weekly Reader* article on crop damage by grasshoppers]

Which of these sentences BEST states the main idea of the article?

% of Students Gr 4		
30	A.	The swarms went from field to field, eating farm crops.
7	B.	There are millions of them, people say.
17	C.	You couldn't step without squashing dozens of grasshoppers.
45	*D.	And millions of grasshoppers meant big problems for farmers.

[Passage: Story of a man's ruse to bring about the acceptance of potatoes as a food source in a famine-struck land. Before the potatoes were ready for harvesting, the potato field was guarded and called a "treasure garden."]

Which of the following statements **best** explains the theme of this passage?

% of Students Gr 8	Gr 12		
19	38	*A.	People want what they cannot have.
2	3	B.	The people in Paris were thieves.
52	30	C.	Potatoes are fine for people to eat.
27	30	D.	Antoine Parmentier was very clever.

[Passage: Article about a school lunch program which offers students the "junk" foods they desire, but fortifies them with important nutrients unbeknownst to the students]

Which of the following best states the main idea of this article?

% of Students Gr 12		
26	A.	The Las Vegas school district fortifies its lunch with vitamins to meet USDA requirements.
20	B.	Len Frederick, a retired food chain executive, has made the Las Vegas school lunch program profitable.
46	*C.	Las Vegas' innovative and profitable school lunch program has received mixed reactions, especially from nutritionists.
8	D.	The Las Vegas school lunch program teaches deception because students are not informed that their food has been fortified.

Too many students mistakenly identify either concrete, factual statements or ideas explicitly stated in the text instead of the broader ideas sought. Apparently, many students read a variety of works of different genres (poems, fables, "content" pieces, etc.) without ever grasping the essential points or thoughts the authors intend to convey.

Mathematics. Grade 4 students (and therefore, grade 8 and 12 students) have a pretty good understanding of whole number numeration in terms of place value, expanded notation, number lines, etc. Students at all three grade levels can identify simple fractional parts from shaded figures. However, conceptual understanding of fractions beyond that appears to be lacking at all grades. Only a third of the fourth graders knew that 1/2 is greater than 1/3, 1/4, and 1/5. Only 60 percent of the eighth graders selected 1/2 as being between 1/3 and 3/4. Understanding of decimals and percentage is generally very poor.

Students can recognize geometric figures; however, their understanding of properties of figures appears lacking. At grade 4, students failed to recognize a square as being a rectangle when it was depicted in a strange position — with vertices pointing up and down. Forty-two percent and 58 percent of the eighth and twelfth graders respectively knew that if a triangle has two equal sides, then it must also have two equal angles.

Not surprisingly, students performed well on routine, one-step word problems, but faltered in multistep or nonroutine situations. Practical or consumer problems are often multistep. Sixty-two percent of the students at grade 4 could determine the change from $2 in the purchase of three items. Forty-six percent of the grade 12 students could determine the miles traveled on a trip given the appropriate odometer readings. (Another 25 percent selected an answer with only the decimal placement wrong.) Half of these

older students could determine how long to cook several potatoes at one time in a microwave oven. Forty-one percent and 66 percent of the students at the upper two grade levels could determine how far to move a picture to center it on a wall.

In problem-solving skills, grade 4 students appear more proficient at identifying missing information rather than extraneous information. Below are the results for eighth and twelfth graders on "relevant information" questions.

Maria left at noon to take a trip on her bicycle. She rode 5 miles each hour. Later that afternoon, Amanda decided to go after her. Amanda rode 10 miles each hour.

What else would you need to know in order to find how far the girls rode before Amanda caught Maria?

% of Students Gr 8	% of Students Gr 12	
4	1	A. the type of bicycle Amanda rode
22	22	B. the time when Maria arrived at her destination
17	13	C. the time when Maria left
57	65	*D. the number of miles Maria had ridden when Amanda left.

Lucy filled her gas tank before she left on her car trip. She refilled it after traveling 264 miles. She put 12.3 gallons of unleaded gasoline into the tank, and it cost her $18. How many miles does she get on one gallon of gasoline?

What information in the above problem is not needed to solve the problem?

% of Students Gr 8	% of Students Gr 12	
11	5	A. the number of miles Lucy traveled
11	5	B. the number of gallons of gasoline she filled up with
54	68	*C. the cost of the gasoline
23	21	D. All of the information above is needed.

Students' skills at estimating and assessing reasonableness appear adequate; however, their responses to actual problems calling for these skills suggest that they tend not to apply them.

Sixty-four percent of the fourth graders could read a ruler marked in quarter inches to the nearest half inch. Yet only 38 percent of these students (43 percent at grade 8 and 44 percent at grade 12) could identify a task in which it would be desirable to measure as accurately as to the nearest inch.

Sixty-five percent and 76 percent of the eighth graders were sucessful on questions requiring them to compute averages. Eighty-three percent of the twelfth graders sucessfully computed the average of ten scores. However, only 41 percent and 55 percent of the eighth and twelfth graders respectively knew that the average of two numbers is halfway between them.

III. THE LACK OF IMPORTANT PIECES OR CONNECTIONS (E.G., VOCABULARY, KNOWLEDGE OF WHEN TO APPLY PROCEDURES, AND OTHER BASIC, CRITICAL UNDERSTANDINGS) OFTEN STANDS IN THE WAY OF SUCCESS.

While the first two major findings suggest that having the prerequisite knowledge for a task does not guarantee successful performance, there are occasions when certain prerequisites are missing. The third major finding pertains to such occasions.

Social Studies. As one might expect, fourth graders performed better on questions in sociocultural environment that pertained to self, family and community than on questions involving societal or international matters — a finding consistent with curricular emphases. Older students were weak on comparative cultures. Presumably, many shortcomings related to these topics are due to their lack of emphasis in the general curriculum. The expanding environment approach to elementary social studies instruction has recently come under fire because of its inadequacy in conveying a sense of history or awareness of the past and the tendency of programs to shortchange anything beyond the "community" level. The inattention to many aspects of sociocultural studies extends through junior and senior high school, the latter because of limited enrollments in electives that cover this ground.

A major concern of committee members reviewing results is the possibility that students' lack of a good working social studies vocabulary could handicap them. "Deter," "specialize," "urban," "rural," "discrimination," "desegregation," "economy," "civil rights," "equitable," "commerce," "interstate," "customs," "population distribution" are examples of words that may not be understood sufficiently. The

committee's concern for vocabulary should not be taken as an argument for emphasizing vocabulary (in isolation) for vocabulary's sake in instruction. Rather, instruction should deal with such terms in larger, memorable contexts.

Science. In the area of data gathering and reduction, grade 4 students performed acceptably on questions about appropriate instruments, what to measure, how to sort, how to collect information on a topic, etc. At all three grade levels, however, important understanding of the concepts of measurement is lacking. In one item in which the students were told that three students arrived at three different measurements for the length of a board, only 57 percent of the fourth graders said that this finding showed that measurement is not exact. Twenty-three percent claimed that this showed the length of the board can change. Fifty-eight percent of the eighth graders and 65 percent of the twelfth graders recognized that multiple measures of the same object should be close but not exactly the same. Only 43 percent of the eighth graders attributed variations in different students' measurements of an object to "human error." Generally, then, students have a lot of measurement skills, but lack some fundamental understanding of measurement.

In the areas of life science, earth and space science, and physical science, as we have seen, there are instances in which students have relevant specific information but fail to see broader concepts. There are also areas in the sciences, however, where students reveal some vague, general knowledge when some specifics would be important to know—for example, in nutrition.

Over three-fourths of the fourth graders realized the importance of sleep, diet, and exercise for good health. However, only 43 percent of fourth graders, 62 percent of the eighth graders, and 70 percent of the twelfth graders could identify a food that would make a meal more balanced. Approximately half of the eighth and twelfth graders knew that lean meat (one of several foods listed) provides the most protein. Approximately the same number of students recognized the importance of carbohydrates for quick energy.

For many topics within the physical sciences, unfortunately, students lack both lower-level and higher-level knowledge. The concept of heat, kinetic theory, and the gas laws reveal this. Just over half of the eighth graders could distinguish among the diagrams of the molecules of the solid, liquid, and gaseous state of a material; on another question, the same number indicated that the difference between solids, liquids, and gases is related to the difference in the speeds at which molecules move. This poor understanding of a very basic concept probably explains why only 40 percent of the eighth graders and 43 of the twelfth graders could determine that a cubic foot of liquid water contained more molecules than a cubic foot of steam. Only 43 percent of the twelfth graders realized that the pressure in an automobile tire would decrease at night, and only 39 percent of the twelfth graders could associate a decrease in volume with an increase in pressure of a gas.

Reading. **External analysis** of text refers to the important but often neglected set of reading skills that help the reader to "set the stage" for reading. Prior knowledge of and experience with the type of reading material and the subject matter are the focus of external analysis, which involves the identifying and recalling of information necessary for evaluation. **External evaluation** includes the skills involved in making decisions about the reading process (e.g., initial strategy selection, self-checking, strategy adjusting). Such decisions are made throughout the reading of a piece. Attention to many aspects of reading/comprehension management is relatively new in instruction and testing. Consequently, the assessment results pertaining to this process are discussed here under the third general finding about lacking fundamentals.

The strengths and weaknesses within the category of external perspective appear to be consistent across the grade levels. Performance is stronger on questions dealing with reasons for italics and bold print, author's tone, and the purpose of the passage. Identifying the genre of a piece is an objective yielding mixed results. The poorest results occur in areas addressing more directly the information used in the readers' decision making regarding the reading process. Questions that seem to be problematic for students across the grade levels involve:

- knowledge that would be most helpful to the reader to understand the concept or passage;
- purpose of a given paragraph (e.g., to arouse interest, transition);
- reason for author's questions or side remarks;
- self-checking questions that would be most beneficial for the reader to answer;
- use of subtitles for finding specific information quickly;
- how to read a particular type of work most effectively for a particular purpose;
- prediction of type of information to come or other characteristics of the piece based on clues in title, heading, or early paragraphs.

Sample questions and their results are shown below:

[Passage: Poem ending with an unfinished line the reader can complete using various clues in the poem]

What is happening in this poem?

% of Students Gr 4		
6	A.	A person is reading a book when the doorbell rings.
7	B.	A person is watching an animal movie.
82	*C.	A person is dreaming when the alarm clock goes off.
6	D.	A person is looking at a painting.

Which statement BEST describes how the title helped you to understand this poem?

% of Students Gr 4		
13	A.	It completed the rhyme.
7	B.	It helped describe the characters.
72	*C.	It was a clue to what was happening.
7	D.	It is repeated through the poem.

[Passage: Article about a school lunch program which offers students the "junk" foods they desire, but fortifies them with important nutrients unbeknownst to the students]

What question could you ask yourself to check your understanding of paragraph 10?

% of Students Gr 12		
13	A.	What kind of food was eaten?
11	B.	What kind of poison was put into the food?
58	*C.	What is Pavlovian conditioning?
17	D.	Have they performed these experiments on people too?

What kind of knowledge would help you **least** to understand this essay?

% of Students Gr 12		
13	A.	knowledge about ethnic foods
22	B.	knowledge about evolution
47	*C.	knowledge about fast foods
16	D.	knowledge about experiments

[Passage: Newspaper article about a town meeting held to approve or disapprove plans for an outdoor rock concert]

If you are given a question asking how many people spoke in favor of the concert and how many were opposed, what is the most efficient strategy you could use to find the answer?

% of Students Gr 8	Gr 12		
11	6	A.	Read the article three or four times, or until you remember everyone's position, then answer the question.
10	9	B.	Read the article through once and estimate the answer, based on what you can recall.
13	13	C.	Scan the article looking for people's names, then write them down.
67	70	*D.	Read the article through once, then go back and underline people's names. Put a plus or minus next to each name, depending on that person's position.

The first question is not really a "reading management" question. It is included here to show the large number of students who could identify what was happening in the poem. Yet a smaller percentage of students recognized the importance of the title to their comprehension. Without the title "Alarm Clock," there is no evidence that would lead a student to the correct response.

The questions pertaining to the school lunch article reveal an inability of many students to identify areas of relevant prior knowledge and appropriate questions to ask oneself to check one's understanding. The passage associated with the last question quoted many of the arguments made by different townspeople at the town meeting. While the students were moderately successful on the question, too many chose answers that were not at all reasonable.

The correct response to the last question included the idea of going back to the passage after reading it the first time. Interestingly, many of the other questions on this passage could not be answered without referring back to the passage (Whose statement was an appeal for sympathy? Whose was most influenced

by financial concerns?). The MEAP advisors were generally disappointed in the results on these and many other questions requiring "going back to the text."

Undoubtedly, students have not encountered many reading process questions in tests. However, comprehension is an outcome of reading. What we should be teaching is how to read; the activities represented in these questions are the activities a student needs to master to become a good reader. Good readers think about the text and about how they will deal with it. Thus, the assessment results suggest that students are lacking in experience or exposure to many "reading management" concepts or activities. In addition to a lack of instruction devoted to reading strategies, the lack of another kind of prior experience may be a hindrance for many students. If familiarity with different genres is important to students in deciding how to approach reading matter and what to look for, then exposure to a wide variety of types of reading matter is essential. The failure of some students on some assessment questions could be the result of limited exposure.

Mathematics. Students at all levels are proficient at performing whole number computations, even though their understanding of the algorithms may be lacking. (See the two grade 4 questions below.)

$$\begin{array}{r} 35 \\ \times\ 3 \\ \hline 915 \end{array}$$

Andrew multiplied the numbers above. Which statement below is true?

% of Students Gr 4	
45	*A. Andrew does not understand place value.
41	B. Andrew does not know his multiplication facts.
14	C. Andrew's answer is correct.

$$\begin{array}{r} {}^{3}\not{2}{}^{1}\not{4}5 \\ -\ 37 \\ \hline 208 \end{array}$$

A student subtracted the numbers above. What does the new top number really mean?

% of Students Gr 4	
67	*A. 2 hundreds, 3 tens, 15 ones
11	B. 2 hundreds, 31 tens, 5 ones
5	C. 2 hundreds, 315 ones
16	D. 2 thousands, 3 hundreds, 1 ten, 5 ones

Fractions, decimals, and percents continue to pose problems for many students across the grades, both conceptually and at lower procedural levels. In dealing with fractional numerals of all types, performance of routine tasks seems particularly inhibited by lack of conceptual understanding. Only two-thirds of the eighth grade students could find 2/3 of 9. The same number of twelfth graders knew that 125 percent of a number could be found by multiplying by 1.25. (Only half of the grade 8 students and two-thirds of the grade 12 students knew that 125 percent of 10 is greater than 10.) Only 28 percent of the eighth graders and 42 percent of the twelfth graders knew that to find 4/5 of a number, one could divide by 5 and multiply by 4. This is particularly disappointing since multiplying or dividing by a fraction often makes little sense, making students' decisions about which operation to use very difficult. In this instance, a good problem solver would reason, "If I divide by 5, I'll get one-fifth of the number; then I can multiply by 4 to get four-fifths of it." This thought sequence can be most helpful in dealing with percentages and other situations requiring proportional reasoning (e.g., "30 is 15 percent of what number?" — "If I divide by 15, I'll get 1 percent of the number; then I can multiply by 100 to get 100 percent of it.").

At all three grades, student understanding of properties of operations is lacking. Fewer than half of the fourth graders could select the number to go in the boxes in the number sentences $3 + 2 + 4 = 3 + \square$ and $28 + \square = 74 + 28$. Generally, between a half and two-thirds of the eighth grade students could identify the true or false number sentence given a set of number sentences illustrating the properties.

The students at the upper two grades have little understanding of variables and relationships. Just over two-fifths of them could identify the equation ($t = 2p$) showing that the number of tomato plants is equal to twice the number of pepper plants. Just over half of the twelfth graders knew that if $y = 5/x$, then as x increases, y decreases. Most twelfth graders have at least one year of algebra behind them, and such rudimentary concepts should not be unfamiliar.

Simple substitution problems and solving simple linear equations appear to be the highest level of algebraic activity that reasonable numbers of eighth and twelfth graders can handle. Sixty-five percent

of the eighth graders and 76 percent of the twelfth graders picked the correct response to $2x - 5 = 31$. Sixty-four percent of the eighth graders knew that to solve $x + 15 = 30$, one "subtracts 15 from both sides of the equation."

Grade 4 students are quite successful at identifying appropriate measuring instruments for given purposes and reading instrument scales with unitary graduations. Students at all levels have difficulty with nonunitary graduations perhaps because of a lack of experience using them. The concepts of measurement error, accuracy and precision elude students, as do the concepts of area and volume. One test question showed the students several rectangular solids of different dimensions, each composed of small unit cubes. Only 44 percent of the eighth graders and 52 percent of the twelfth graders could identify the rectangular solid (stack of cubes) with a different volume from the other three. Thus, the most basic understanding of volume is not held by many students.

Poor understanding of concepts may also be a major reason for low performance on what should be a relatively simple task involving area. Only 33 percent and 51 percent of the students at the upper grade levels could find the area of a figure that could easily be partitioned into two rectangles.

Students are generally weak at identifying diagrams that might be used to help solve problems, picking the most effective strategies for solving problems, and making "next guesses" in successive approximation situations. See the results depicted below.

Which figure would be most helpful in solving the following problem?

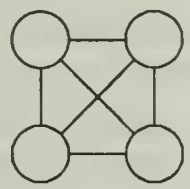
If each of 4 persons shakes hands with each of the other persons, how many handshakes would take place?

Gr 4-Gr 8-Gr 12

A. 35-30-16

B. 15-4-5

C. 22-11-9



*D. 28-54-70

Which strategy would be most effective in solving the following problem?

Nancy and Ronald are standing 10 feet apart. If you had to place a marker every place that is 6 feet from **both** of them, how many markers would you need?

% of Students Gr 12	
34	A. using an equation
7	B. making a table
57	*C. drawing a picture
8	D. using trial and error

It is interesting that while 70 percent of the twelfth graders selected the appropriate diagram for the classic handshake problem above, only 23 percent could solve the problem when an answer was called for and no diagram was provided. Apparently, students still receive limited instruction in problem-solving strategies.

Students can respond successfully to some probability questions intuitively, but they have difficulty with probability questions involving the concept of independence of events and the notion of area as probability (as shown by spinner questions in which sectors of a circle have unequal probabilities of being spun). Inattention to probability in mathematics curricula is a particular concern of professional groups in mathematics education. Students can generally read directly from tables and graphs, but have difficulty drawing appropriate inferences from them. Are they often asked to draw inferences from data? Although high percentages of eighth and twelfth graders can compute a simple average, many do not know that the average of two numbers is halfway between them. Thus, the concept of average is not widely understood.

The proportional reasoning of eighth and twelfth graders is generally poor. Only 39 percent of the eighth graders responded correctly to the question shown below.

A painter is to mix green and yellow paint in the ratio of 4 to 7 to obtain the color he wants. If he has 28 liters of green paint, how many liters of yellow paint should be added?

% of Students Grade 8	
10	A. 11
29	B. 16
17	C. 28
39	*D. 49
4	E. 196

Twelfth graders were given the amounts a person deposited in a savings account and a Christmas club each month and asked how much would be in the savings account when there was a given amount in the Christmas club. Two-thirds of the students were successful. On another problem involving the proportionality of similar triangles, only 29 percent of the seniors found the length of a "missing" side.

Spatial visualization problems were generally nonroutine; therefore, it is difficult to evaluate strengths and weaknesses. However, it is safe to say that large numbers of students found the tasks of determining what an object would look like from a different angle and identifying which figures could be folded into cubes quite formidable.

Assessment advisors suspect that the lack of a basic mathematical vocabulary is a problem. In some instances, vocabulary should not stand in the way of successful performance — for instance, students can still use the properties of operations without having to name them. However, when asked what figures result when one diagonal is drawn in a rectangle, mathematical vocabulary is critical. The vocabulary is needed to communicate.

General Comments

A common statement in the discussion of findings above is, "X percent of the students know Y, but only Z percent do W." The implication of this statement is that students have a great deal of information at their disposal, but are not particularly successful on tasks requiring them to use it. Concern about students' higher order thinking skills is nothing new. However, in the past, the failure of students on many tasks was attributed to their lack of the ability to do higher order reasoning. Careful examination of the MEAP results could lead to a slightly different conclusion. While performance on many higher order tasks leaves a great deal of room for improvement, there are indications that students have a reasonable capacity for thinking; they simply tend not to apply their thinking skills when appropriate. In many instances, it was clear or reasonable to assume that the students possessed the knowledge and skills required to succeed on a question, but failed to do so. The responses many students chose to some questions reveal their tendency to avoid extended thinking, favoring shallow answers or answers found quickly through strategies that can be applied without thinking. Whether the problem is a result of an attitudinal problem or the inability of students to recognize situations when more thought would be helpful is unclear.

Many MEAP questions in all four subjects require the analysis and evaluation of evidence — the two principle forms of critical thinking. The student must play detective in order to analyze information that is either provided or is already a part of his or her base of knowledge. Judging or evaluating evidence involves some risk-taking. There is often an element of "truth" to many answers; the student, however, must weigh the evidence, and then commit himself or herself to a "best" response. Many students do not make that commitment. In reading, they prefer responses that are taken verbatim from the reading passage; in math, they prefer to mechanically apply a computational algorithm when simple reasoning would be more successful. In science or social studies, they appear to be quick to select answers one would expect them to pick if they did not give the question much thought.

Critical thinking experts are greatly interested in students' "dispositions." Are they inclined or disposed to thinking or are they not? The MEAP results suggest that, for whatever reason, many students are not. Is it true that the very young students are more likely to employ higher order thinking skills than older students; and if so, what are we doing to students as they progress through school? Are we treating content areas as bodies of knowledge simply to be transmitted to students and testing accordingly? Are we deceived by the short-term success of rote learning or teaching techniques that relieve the student of the responsibility for thinking? Are we giving students enough practice in thinking?

Another area which thinking experts are studying is the area of metacognition — thinking about thinking. Reading educators are finding that giving instructional attention to metacognitive aspects of the reading process (i.e., bringing decision-making regarding the selection of reading strategies and behaviors to the conscious level) enhances comprehension. Much of the MEAP reading framework's "external perspective" category relates to metacognition. Reading assessment results suggest that students have

limited experience "stepping back" from the reading material and asking themselves about how they might best approach the reading task, what prior knowledge will most likely be helpful, and what clues there are that might help direct their thought processes as they proceed through the reading material. In mathematics, it appears that students have little exposure to various problem-solving strategies, let alone experience in thinking about ways to evaluate alternative strategies. In science and social studies, it seems that students rarely think about how to evaluate several pieces of evidence in support of a conclusion to determine which offers the strongest support when all offer some support.

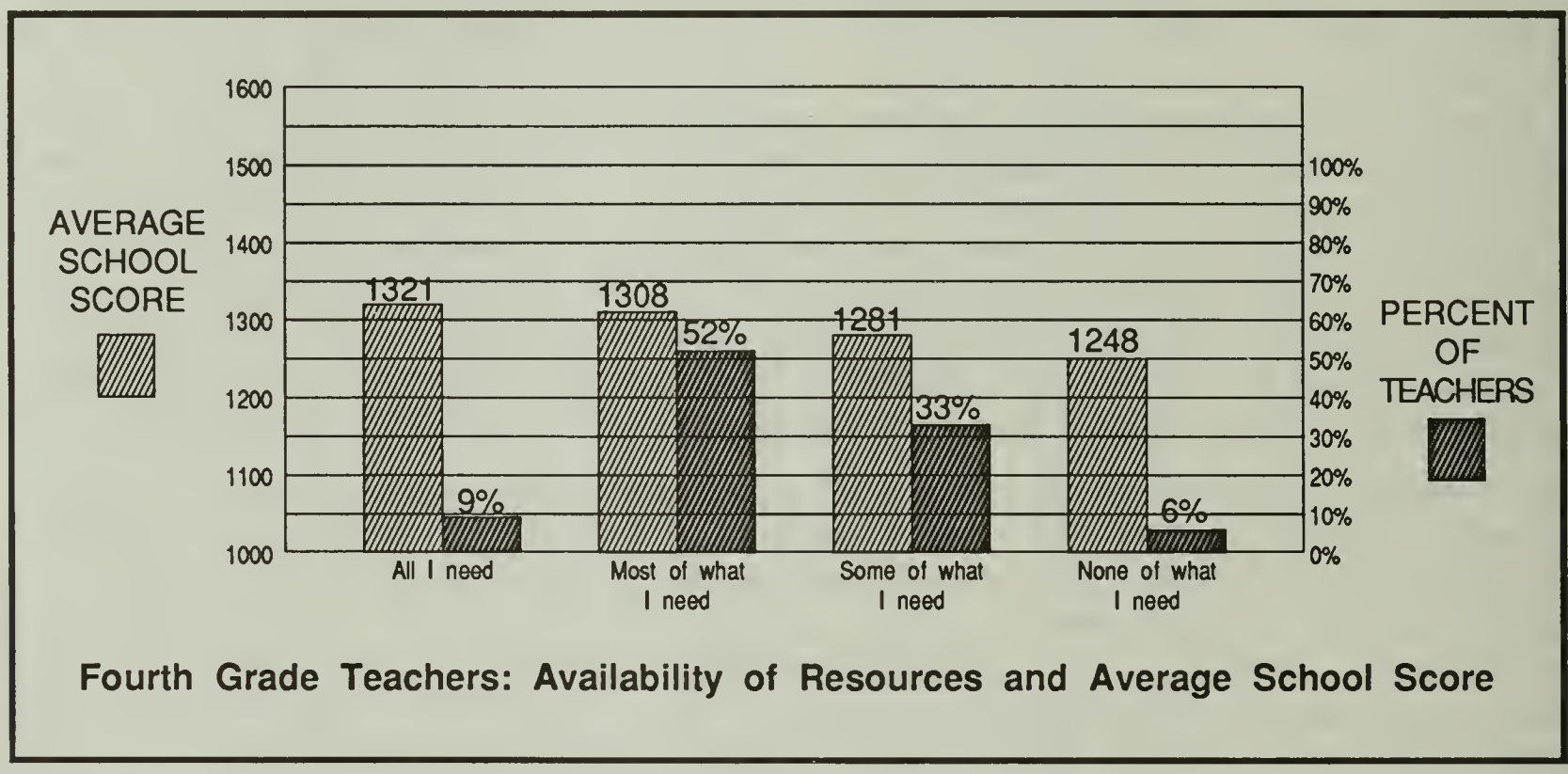
CHAPTER 4: OPPORTUNITIES TO LEARN

Introduction

Although the written curriculum of most schools throughout the state is similar, schools differ vastly in how they translate their written objectives into instructional practice. In other words, despite the common features of their intended curricula, the actual curricula that exist in the schools may be quite different. The **actual curriculum** refers to how the stated learning objectives are translated into instruction. It includes the relative emphasis given to different aspects of the subject area, the courses offered, the resources available and the activities and materials used to help students learn. The Massachusetts Educational Assessment Program used the questionnaires to gather a great deal of information about the actual curricula that exist in Massachusetts schools. This chapter reviews some of those findings and their implications for educational performance.

Grade Four

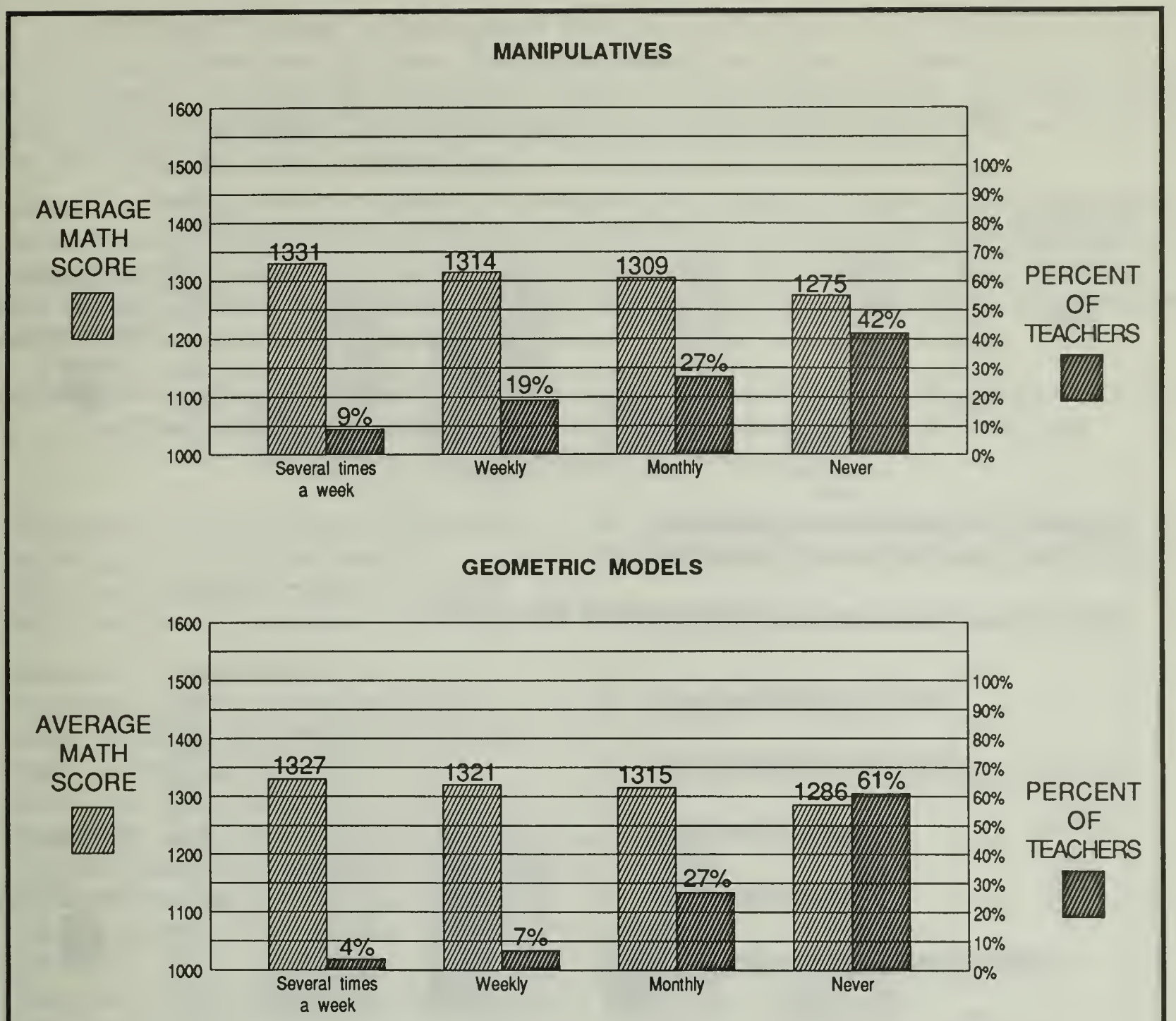
An important factor associated with performance among fourth grade classes was the availability of resources. Schools that scored well on the assessment had more and varied resources. Teachers were asked "what is your situation in regard to instructional material?", with the following results.



Fourth Grade Teachers: Availability of Resources and Average School Score

This association between the general availability of resources and school achievement was confirmed when the questions referred to specific materials. Responses to the principal's questionnaire, which asked about budgetary allocation for scientific equipment and consumable materials, also showed a positive relationship with performance, as did the percentage of classroom teachers who had libraries in their own class. As a general rule, the greater the availability of resources, the higher the school scored on the assessment.

In addition to asking about the availability of resources, the questionnaires examined the extent to which those resources were actually used in the class. Their responses were then related to school performance, with the following results.

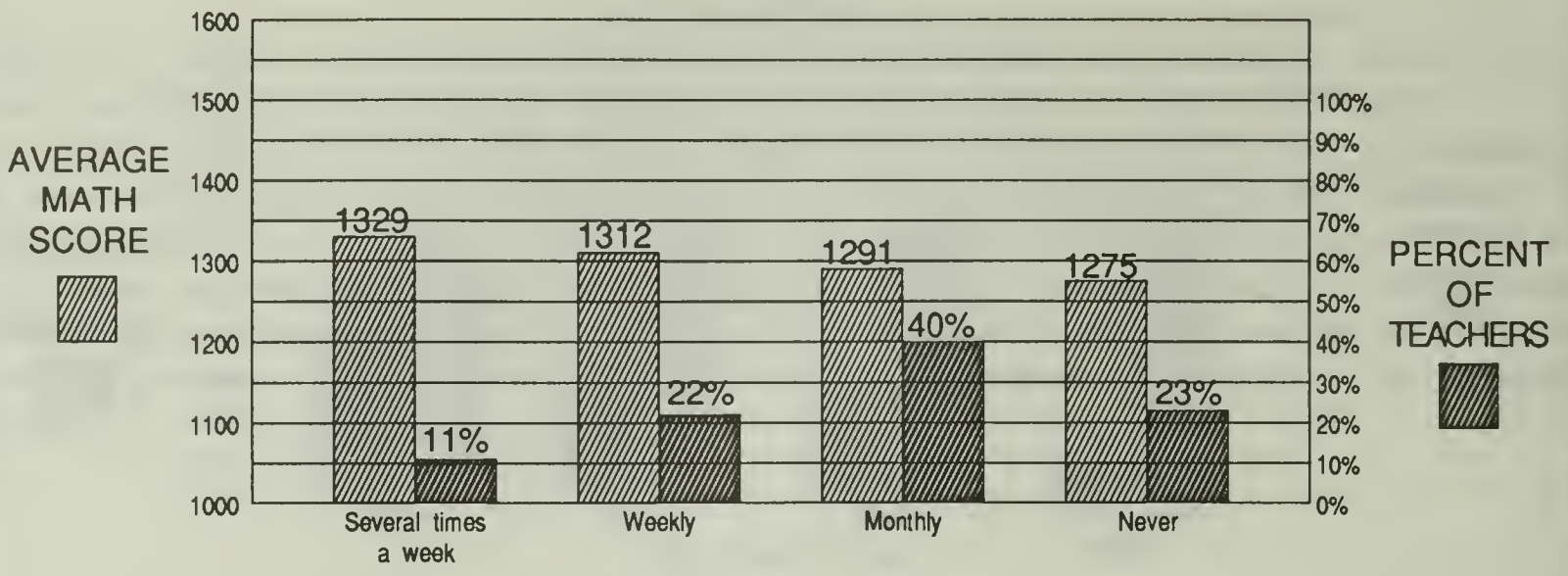


Association Between the Use of Instructional Aids and Mathematics Scores

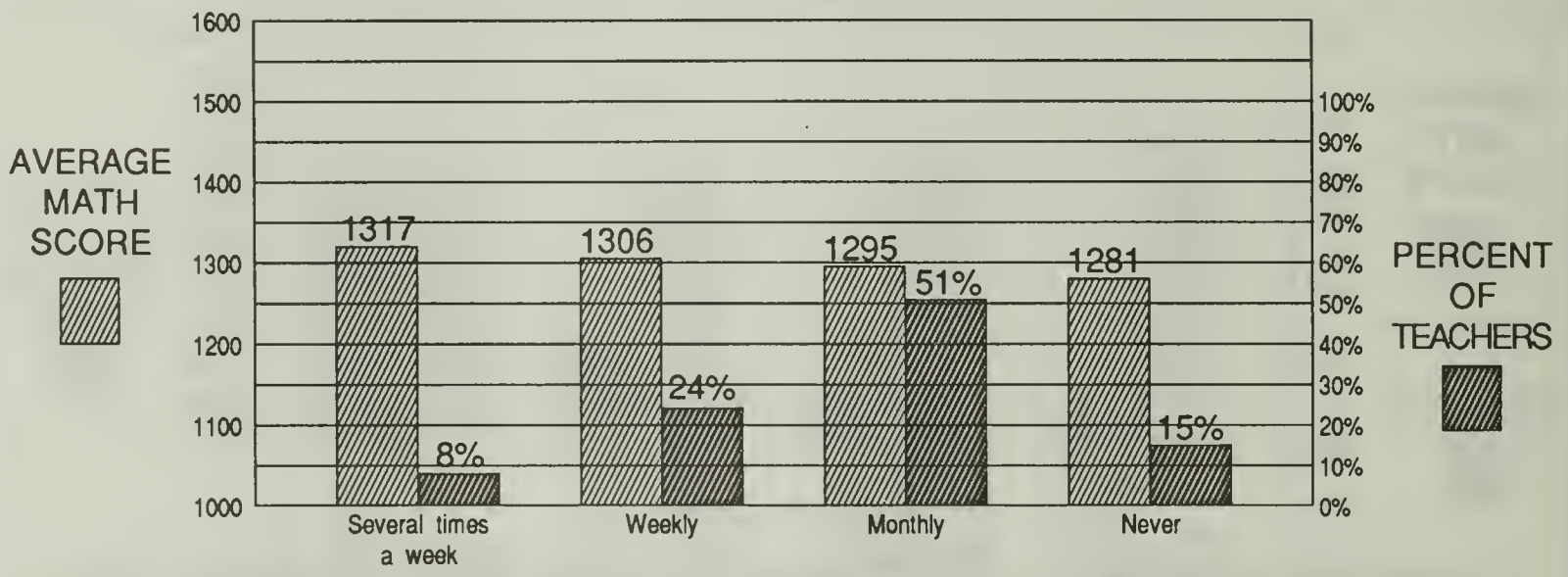
The use of other resources, such as computers, kits, plants and animals in the class, and children's magazines were also associated with higher performance, although the relationship was less strong than in the above items. Approximately half the fourth grade teachers reported using computers for mathematics instruction, and this was associated with high mathematics scores. Another 23 percent used them for social studies, with a similar association.

Questions were also asked about the frequency of different instructional activities. The following were related to school performance.

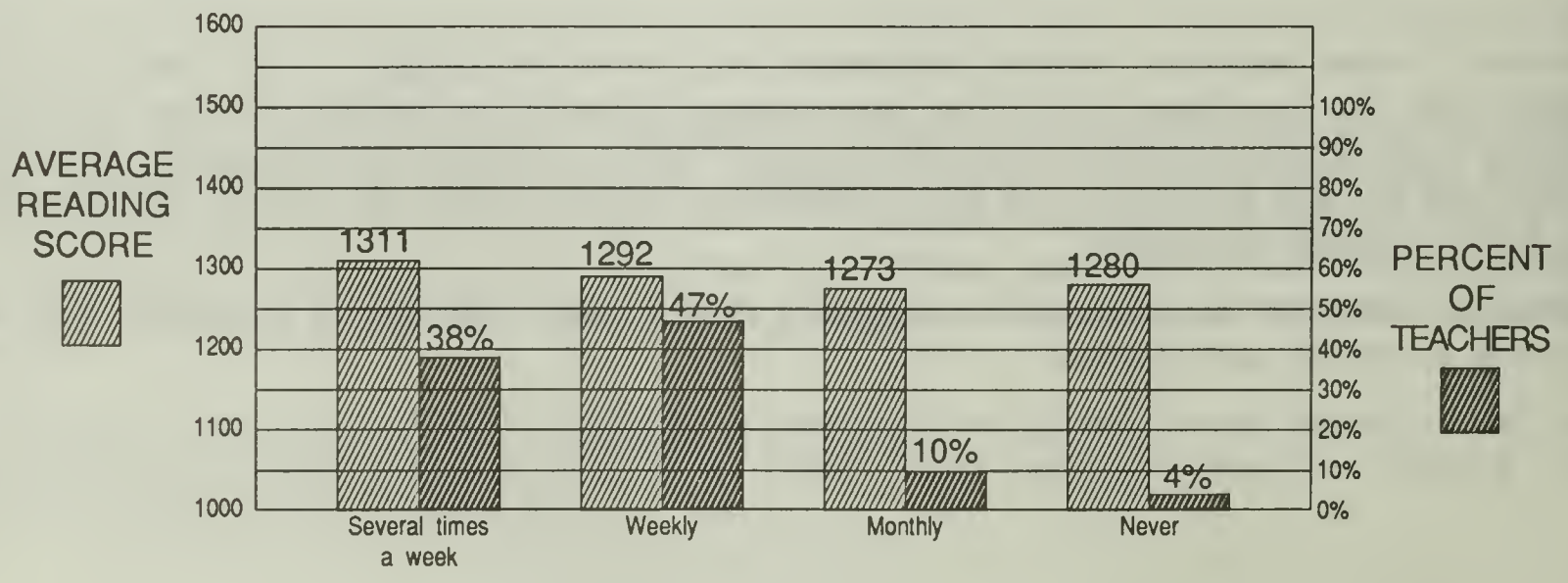
COLLECT DATA



MAKE GRAPHS AND CHARTS



SHARE PAPERS

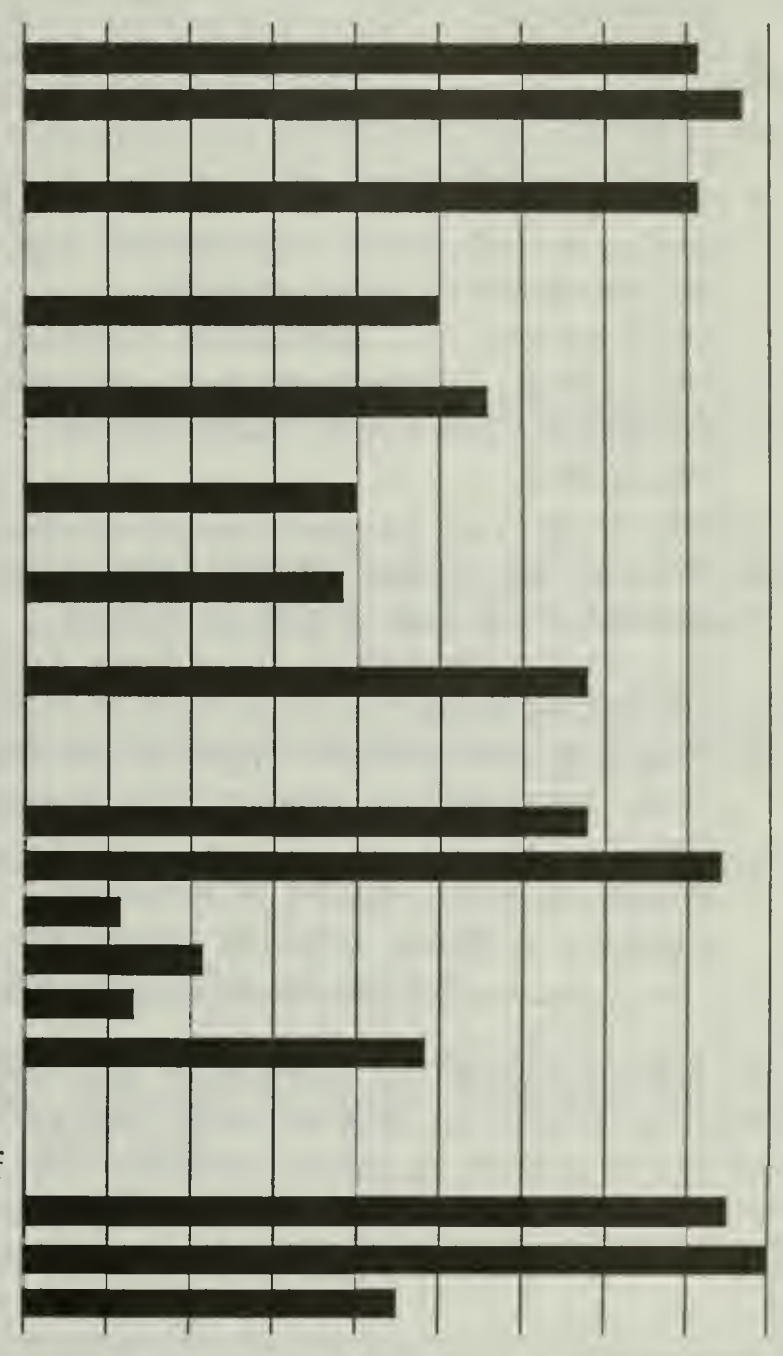


Association Between Instructional Activities and School Scores

On the other hand, the effect of instructional time *per se* is less clear. As a general rule, the more time devoted to a subject area, the better the performance of the school. Differences were particularly apparent in science. None the less, schools that spent more than five hours on any subject tended to have lower scores in that subject. This included reading instruction, where over half the teachers reported spending more than five hours in instruction.

Reading. In reading, over 80 percent of the fourth grade teachers placed the greatest emphasis on word recognition and determining the meaning of words from context. In terms of reading, they stress skills such as locating information in a passage and identifying the main idea. They also stress study skills such as using reference materials and following directions. Relatively few teachers place considerable emphasis on critical evaluation reading skills.

PERCENTAGE OF FOURTH GRADE TEACHERS PLACING CONSIDERABLE EMPHASIS ON DIFFERENT READING TOPICS



- vocabulary (e.g., synonyms, antonyms) 82
- meanings of words from context 88
- literal comprehension (skills at locating information in a passage) 82

Inferential Comprehension

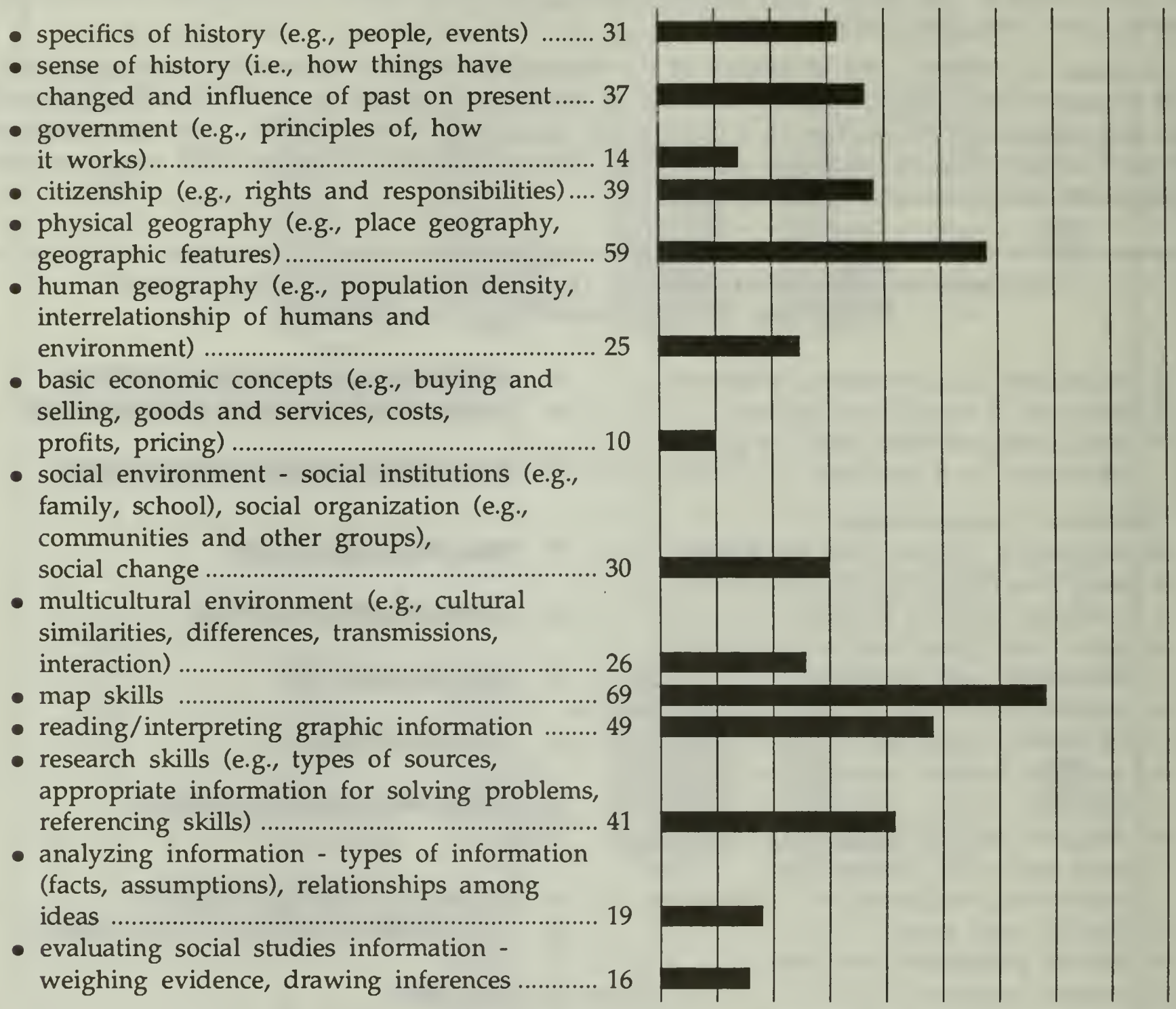
- recognizing relevant prior knowledge 50
- using structural/organizational cues (e.g., headings, italicized words) 56
- make predictions based on genre, prior knowledge, and introductory information 40
- evaluate, select and modify reading strategies for different purposes 39
- recognize types of information (e.g., facts, opinions) 67
- recognize relationships among ideas (e.g., cause and effect, reasons and conclusions, similarities and differences) 67
- identify main ideas 84
- identify progaganda and bias 11
- evaluate evidence 21
- evaluate reliability of sources 13
- evaluate or draw inferences 49

Study Skills

- using reference materials (e.g., dictionary, table of contents) 85
- following directions 90
- classifying or categorizing information 45

Social Studies. In contrast to the curriculum questions in reading, where teachers were asked to describe their fourth grade instruction, in social studies teachers were asked to report on the relative coverage of topics throughout grades 1 to 4. Perhaps as a result of this broader focus, there was far less consensus on the extent to which various topics were addressed. With the exception of economics, which was reported not covered or given little emphasis by almost half of the teachers, most topics were covered to some extent by the majority of teachers. Given below are the percentages of teachers who replied that different social studies topics were given considerable emphasis in their elementary curriculum.

PERCENTAGE OF FOURTH GRADE TEACHERS REPORTING CONSIDERABLE EMPHASIS ON SOCIAL STUDIES TOPICS IN GRADES 1 TO 4


• specifics of history (e.g., people, events) 31
• sense of history (i.e., how things have changed and influence of past on present..... 37
• government (e.g., principles of, how it works)..... 14
• citizenship (e.g., rights and responsibilities).... 39
• physical geography (e.g., place geography, geographic features)..... 59
• human geography (e.g., population density, interrelationship of humans and environment) 25
• basic economic concepts (e.g., buying and selling, goods and services, costs, profits, pricing) 10
• social environment - social institutions (e.g., family, school), social organization (e.g., communities and other groups), social change 30
• multicultural environment (e.g., cultural similarities, differences, transmissions, interaction) 26
• map skills 69
• reading/interpreting graphic information 49
• research skills (e.g., types of sources, appropriate information for solving problems, referencing skills) 41
• analyzing information - types of information (facts, assumptions), relationships among ideas 19
• evaluating social studies information - weighing evidence, drawing inferences 16

In schools where the curriculum was more focused, performance was better. However, as the achievement results for specific items indicate, in many areas students used reasoning or their general knowledge to answer questions correctly. For example, although between 60 percent and 70 percent of the teachers replied that their students had not been taught the information necessary to answer the following questions, approximately 75 percent of their students give the correct answer.

Toys might cost less after Christmas because A. more people want to buy them. B. fewer people want to buy them. C. they cost more to make in the winter. D. store owners do not have sales in the summer.	The best way to earn money helping your neighbor is to offer to do something that your neighbor A. enjoys doing. B. cannot do without special tools. C. does not have time to do. D. likes to do alone.

Discussion

School differences in performance are related to the availability of materials and the kind of activities that children engage in. Students in schools where manipulatives are not used, when graphing is seldom or never done, where computation is stressed over understanding, perform less well on the assessment, particularly on questions that call for conceptual understanding and application. In Chapter 3 it was observed that, although fourth grade students have measuring skills, they lack an understanding of measurement itself. Specifically, they can measure, but they cannot identify a task for which it would be important to measure accurately. They fail to place their skill in context. Similarly, although they can recognize plane figures, they have little understanding of the effect of position on those figures. They can read graphs, but do not know how to interpret them. This type of understanding comes from practical experience—using manipulatives and models, collecting data and making one's own graphs and charts—all of which are activities that form part of the curriculum in schools with high achievement on the assessment.

What is true in the area of mathematics and science is also true in reading and social studies. Schools in which teachers frequently communicate with their students in writing, encourage their students to share papers and to spend time reading silently from books of their own choice perform better in reading. In a similar fashion, schools that emphasize map skills, reading graphical information, research skills, analysis and evaluation perform better in social studies. Not all differences are significant, but the trend clearly indicates that a varied and active instructional program is associated with higher achievement.

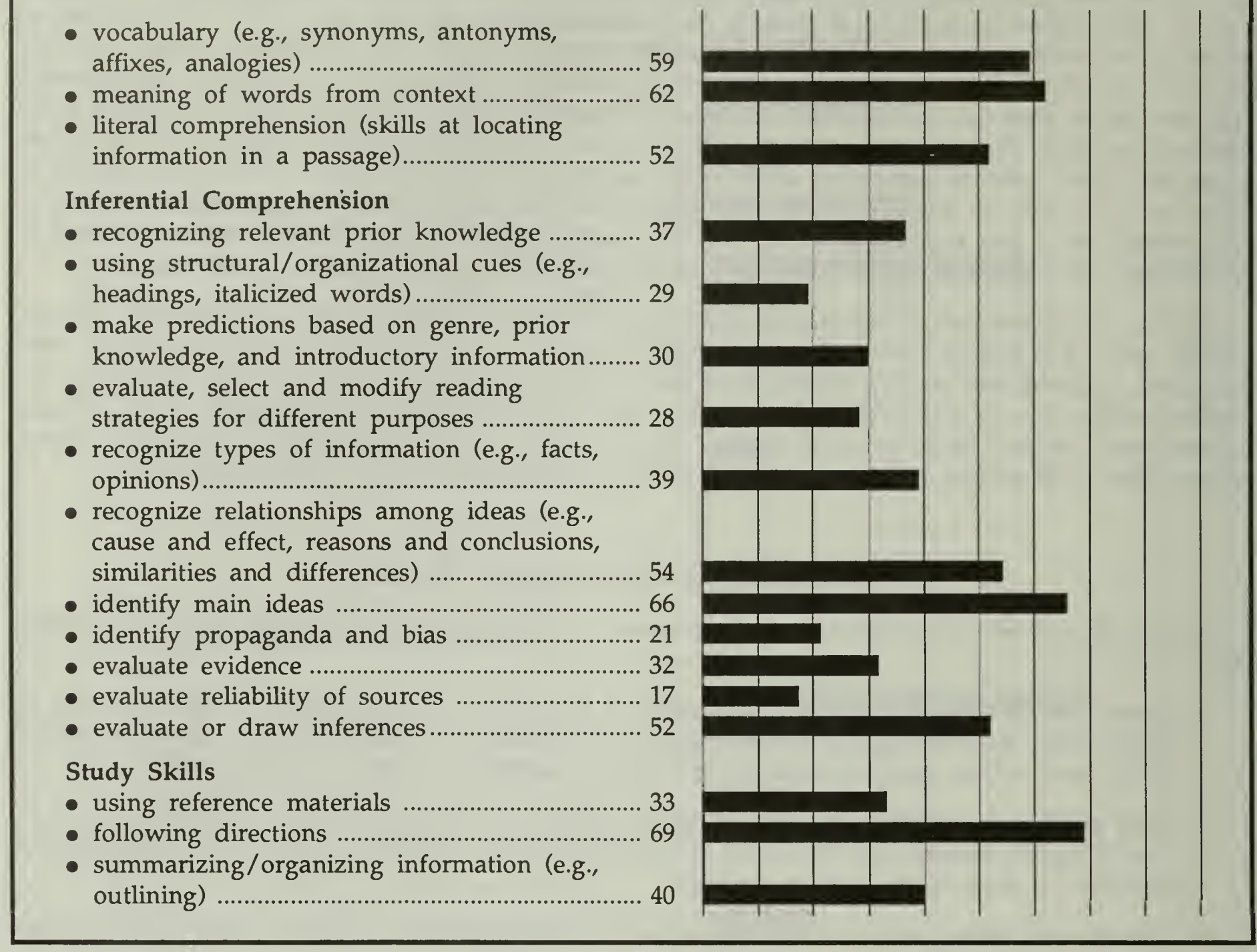
Grade Eight and High School Reading

When practices were compared at the junior and senior high schol levels, a similar pattern of instruction appears.

- Approximately three quarters of the students at both levels are assigned to classes according to ability. This does not appear to affect the kind of courses they are taking, except at the lower ability level, where more students are enrolled in remedial reading or reading laboratories.
- Study skills form an important part of the curriculum at both grade levels. Eighty-three percent of eighth grade teachers and 73 percent of high school teachers indicate that they place considerable emphasis on these skills in their teaching.
- Aproximately three quarters of teachers at both levels expect their students to discuss and analyze what they have read.
- More than half engage in activities to activate prior knowledge of content.

When asked about the emphasis placed on different aspects of the reading curriculum, eighth grade teachers, like their colleagues in the elementary grades, appeared to stress vocabulary and literal comprehension over the more analytic and evaluative reading skills.

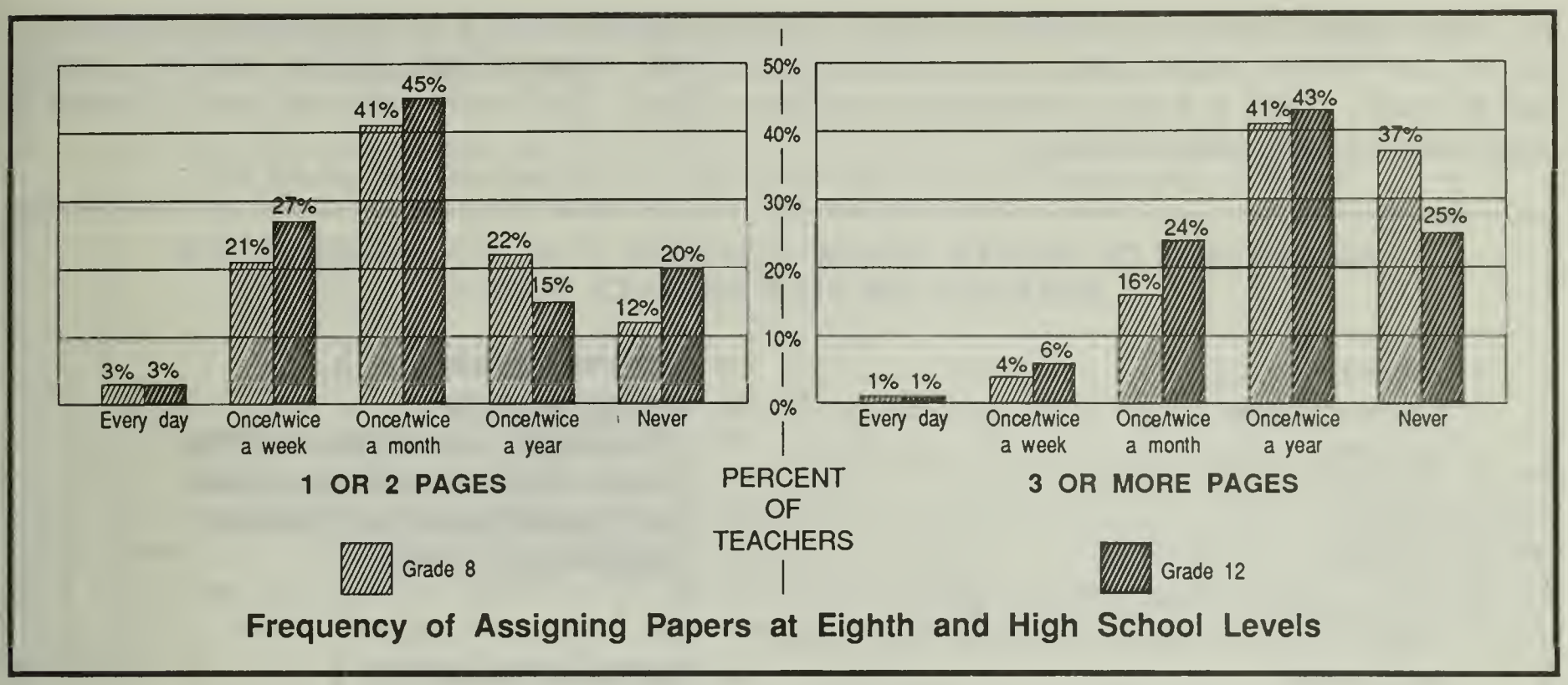
PERCENTAGE OF EIGHTH GRADE TEACHERS PLACING CONSIDERABLE EMPHASIS ON ASPECTS OF READING.


• vocabulary (e.g., synonyms, antonyms, affixes, analogies) 59
• meaning of words from context 62
• literal comprehension (skills at locating information in a passage)..... 52
Inferential Comprehension
• recognizing relevant prior knowledge 37
• using structural/organizational cues (e.g., headings, italicized words)..... 29
• make predictions based on genre, prior knowledge, and introductory information..... 30
• evaluate, select and modify reading strategies for different purposes 28
• recognize types of information (e.g., facts, opinions)..... 39
• recognize relationships among ideas (e.g., cause and effect, reasons and conclusions, similarities and differences) 54
• identify main ideas 66
• identify propaganda and bias 21
• evaluate evidence 32
• evaluate reliability of sources 17
• evaluate or draw inferences..... 52
Study Skills
• using reference materials 33
• following directions 69
• summarizing/organizing information (e.g., outlining) 40

This pattern of emphasis is repeated throughout the various ability levels with some exceptions. As in the case with elementary reading instruction, the use of structural cues in reading is stressed with lower achieving classes, while the evaluation of evidence forms a greater part of the curriculum at the upper achievement levels.

Teachers at the high school level followed much the same emphasis, although there was more stress on evaluation than at the earlier grade.

The pattern of similarity in instructional methods and demands on the students is particularly apparent when teachers at the two grade levels were asked to indicate the frequency with which they assigned papers of different lengths. The majority of teachers assign very short papers to their students once or twice a month, while papers of moderate length are usually assigned on a yearly basis at both grade levels.



Frequency of Assigning Papers at Eighth and High School Levels

This similarity in instructional demands is also apparent in homework assignments. Thirty-five percent of eighth grade teachers and 39 percent of high school teachers stated that their students needed between 2 and 4 hours a week to complete their reading/English homework. Nineteen percent of high school teachers and 5 percent of eighth grade teachers estimated more time was needed. In contrast, when students were asked the same questions, only 18 percent of both eighth grade students and twelfth grade students replied that they spent that much time. Most spent less time, although 7 percent of eighth graders and 10 percent of high school students spent more than 4 hours on homework.

At the student level, the extent of writing and the amount of time spent on homework is strongly associated with performance. Yet there seems to be little increased emphasis as students mature in their education.

At the earlier grade level, end-of-unit tests and quizzes, along with homework, are the most frequently used methods of evaluation. While end-of-unit tests and quizzes are given considerable weight at the high school level, mid-year and final exams and class discussions also play a major role.

Discussion

Instructional emphasis and demands are very similar between grade levels. The number and type of written work required of students increases little as students progress. This is also the case with homework assignments. Even the curriculum emphasis does not show a dramatic change from that at the elementary level.

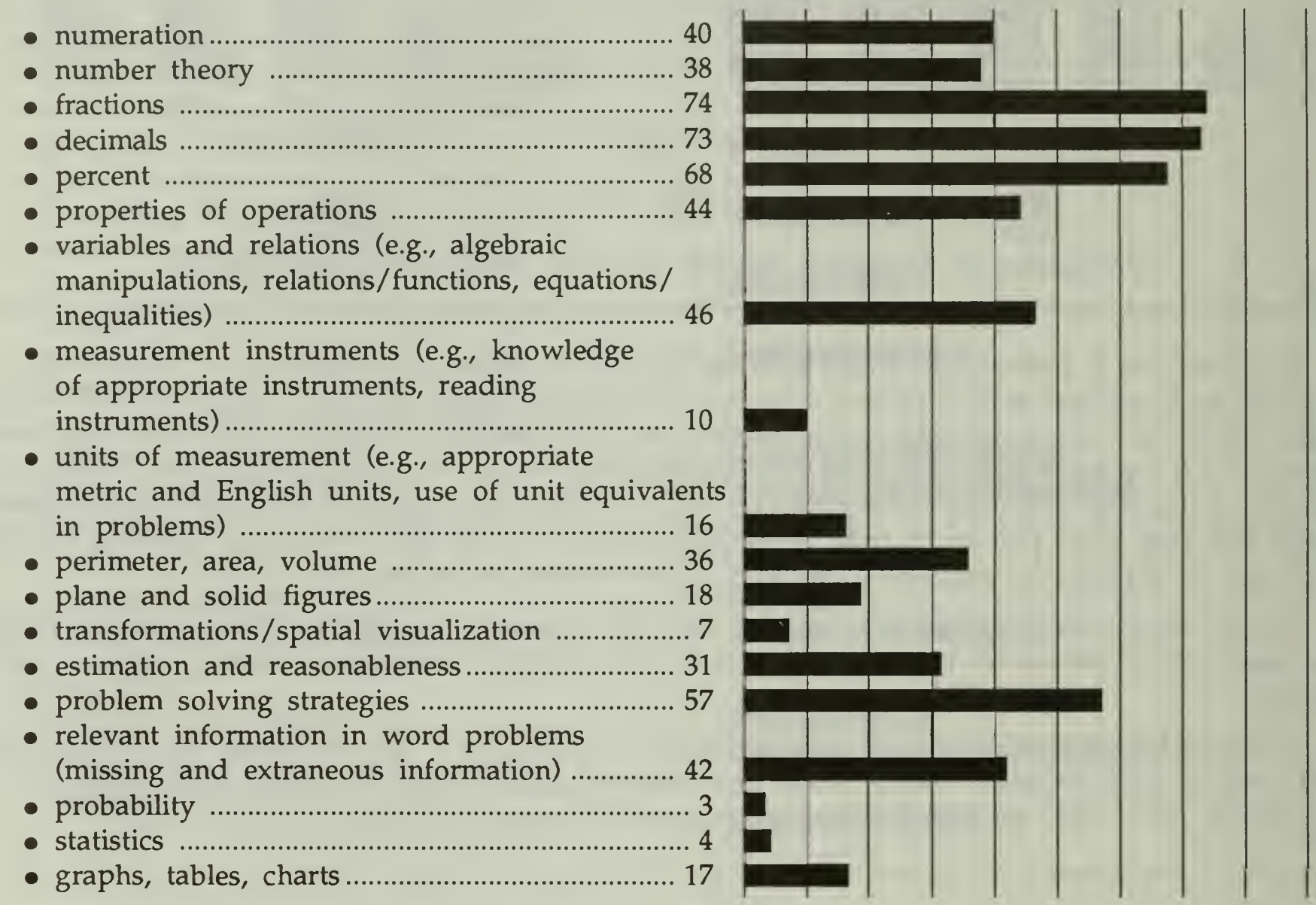
Current views of the reading process and its relevance to instruction are discussed in Chapter 3. From the assessment survey, there is little evidence that teachers are stressing the analytic and evaluative skills that are advocated by reading experts. Nor are they emphasizing the external, or metacognitive, aspects of reading. These include recognizing the characteristics of different genres and using this knowledge to select and modify reading strategies.

Grade Eight and High School Mathematics

Unlike reading or language arts, in which the subject matter and instructional approach are similar across ability levels, by eighth grade students of differing mathematical achievement are taking very different course work. Of the eighth grade students participating in the assessment, 23 percent were studying algebra, 33 percent pre-algebra, 41 percent general mathematics, and 2 percent were in a remedial mathematics course.

When eighth grade teachers were asked for the emphasis that they place on various mathematics topics, it was clear that the topics given most emphasis are primarily computational, such as fractions, decimals and percents. There is a some emphasis on problem solving. The least amount of time is devoted to geometry, probability and statistics.

PERCENTAGE OF EIGHTH GRADE TEACHERS PLACING CONSIDERABLE EMPHASIS ON MATHEMATICS TOPICS


• numeration 40
• number theory 38
• fractions 74
• decimals 73
• percent 68
• properties of operations 44
• variables and relations (e.g., algebraic manipulations, relations/functions, equations/ inequalities) 46
• measurement instruments (e.g., knowledge of appropriate instruments, reading instruments) 10
• units of measurement (e.g., appropriate metric and English units, use of unit equivalents in problems) 16
• perimeter, area, volume 36
• plane and solid figures 18
• transformations/spatial visualization 7
• estimation and reasonableness 31
• problem solving strategies 57
• relevant information in word problems (missing and extraneous information) 42
• probability 3
• statistics 4
• graphs, tables, charts 17

When responses were examined in terms of the level of students taught (remedial, typical or enriched/ accelerated), the largest difference in emphasis occurred for variables and relations, which form a large part of the algebra and pre-algebra courses. However, differences occurred in terms of all the non-computational topics.

Reasoning processes are emphasized primarily with students of higher ability, as indicated when teachers responded to specific items from the test. For example, although fractions and numeration were given considerable emphasis by all teachers, fewer than half of the remedial teachers stated that they had taught the necessary information for students to answer the following item, while 82 percent of the enriched and 71 percent of the typical had done so.

A painter is to mix green and yellow paint in the ratio of 4 to 7 to obtain the color he wants. If he has 28 liters of green paint, how many liters of yellow paint should be added?

A. 11
B. 16
C. 28
D. 49
E. 196

Similarly, while percent is given considerable emphasis in the curriculum of the remedial classes, the proportion of the teachers with different ability students follow the pattern above.

The price of an article was $100. The price was first raised by 10% and was then reduced by 10% of the new price. What is the price of the article now?

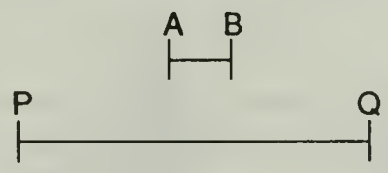
A. $90
B. $99
C. $100
D. $101
E. $110

Chapter 3 discusses the fact that, even when students have adequate conceptual knowledge to reason out an answer, they tend not to make use of that knowledge. Teachers' responses to these items suggests that students may not be provided with opportunities to apply such concepts as ratio and percentages. As a result they may not be familiar with the contexts in which such concepts are used. As a general rule, verbal problems, such as those above, appeared to be seen as appropriate only for the higher levels of ability.

The stress on numerical computation that was discussed previously is particularly apparent in teachers' responses to the question shown below.

The length of $\overline{AB}$ is 1 unit. Which is the best estimate for the length of $\overline{PQ}$?

A. 2 units
B. 6 units
C. 10 units
D. 14 units
E. 18 units



Although 76 percent of teachers of advanced students had covered the information necessary to respond correctly to this question, slightly more than half of the teachers of lower ability students responded affirmatively. Even estimation, which is thought to be given moderate emphasis in all types of classes, is evidently thought of in terms of numbers. When presented in visual form, 21 percent fewer teachers of lower achieving students recognized it as something that their students should be able to answer correctly.

The same pattern applied when teachers were asked about items that measured the understanding of problems.

Laura bought a pair of jeans that were on sale. If the jeans were originally priced at $14.50 and were marked "20% off" for the sale, how much did Laura pay for them?

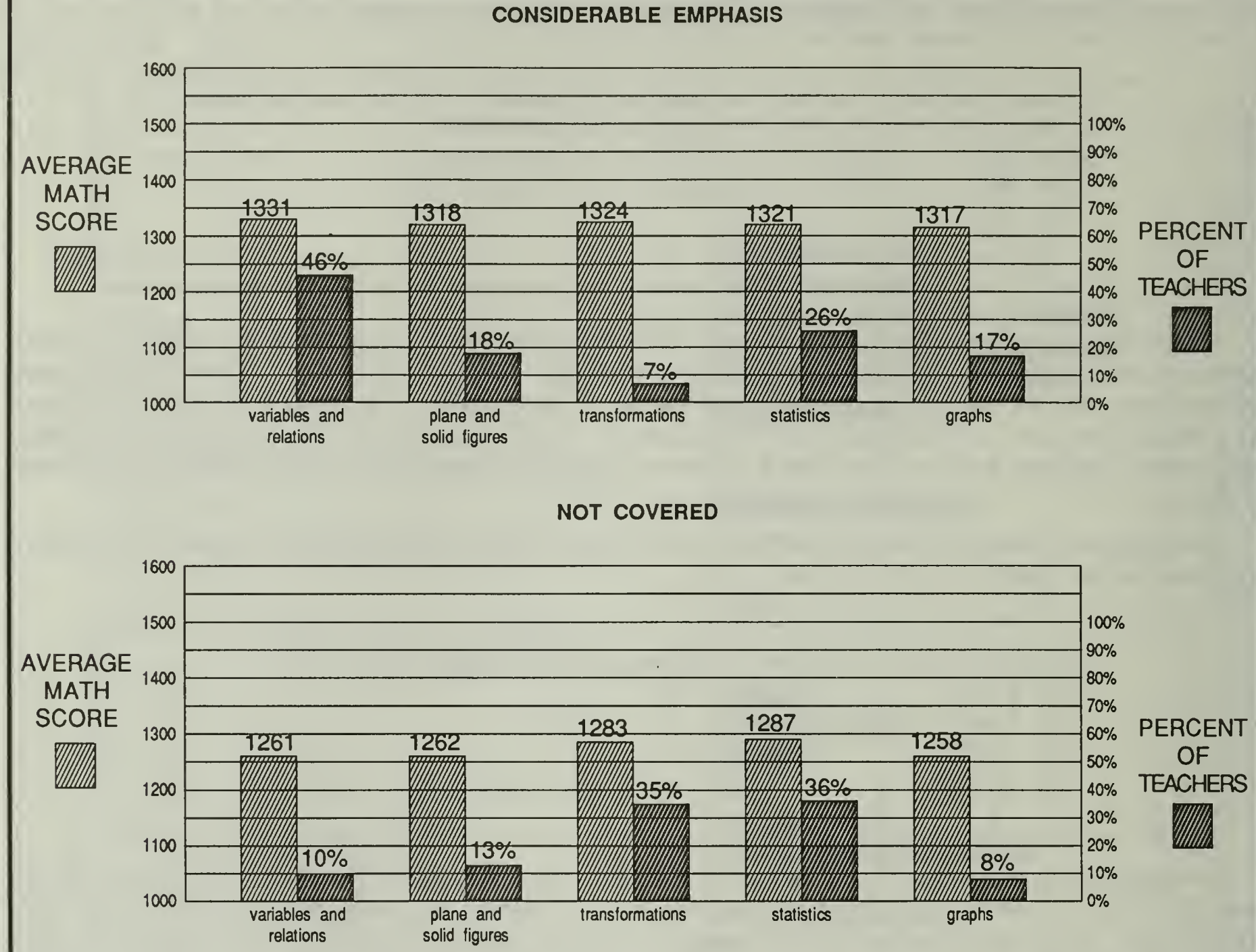
Which problem is **most** like the problem above?

A. A store offered $5.00 off all pictures. What is the sale price of a picture originally marked $20.00?
B. Everything in the store is 1/4 off the original price. What is the cost of a picture originally marked $20.00?
C. A store owner pays $20.00 for a picture and then sells it for 5% more than she paid. How much profit does she make?

Katie wants to find the thickness of one sheet of notebook paper. The paper is so thin she can't measure it with her ruler. She makes a stack of notebook paper that is 10 cm high. What additional information is needed to find the thickness of one sheet?

A. There are about 1200 sheets in the stack.
B. The paper is 22 cm wide and 28 cm long.
C. The lines on the paper are .5 cm apart.
D. The volume of the stack is 6160 cm^3.

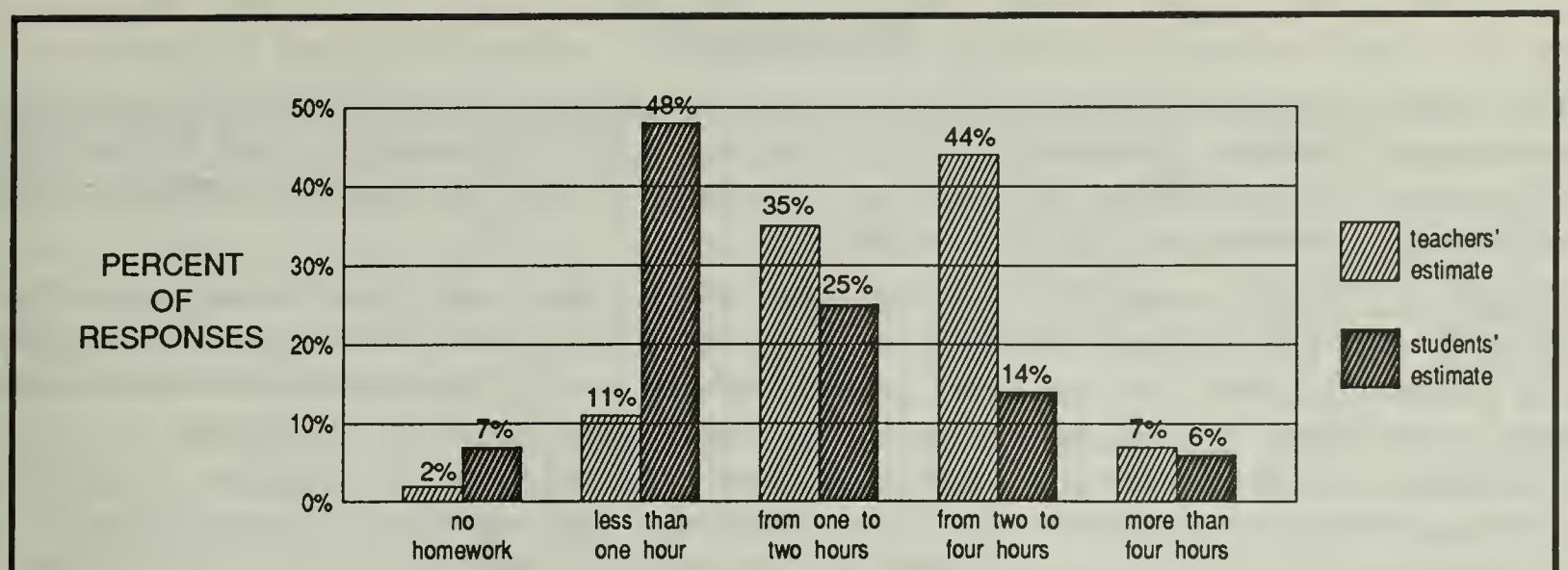
In general, teachers from higher scoring schools emphasized less traditional computational topics more frequently than traditional computation skills.



Extent of Coverage and School Score on Selected Mathematical Topics in the Eighth Grade

In their evaluation of students' progress, teachers from higher scoring schools also placed less emphasis on worksheets, and more on class discussion. As is the case with fourth grade teachers, they tend to use models and other concrete objects to illustrate mathematical ideas and to use group work two or more times a week.

They also tend to assign more homework; however, the time that teachers estimate that their students spend on homework and the homework time actually reported by students varies greatly, as seen in the following table.

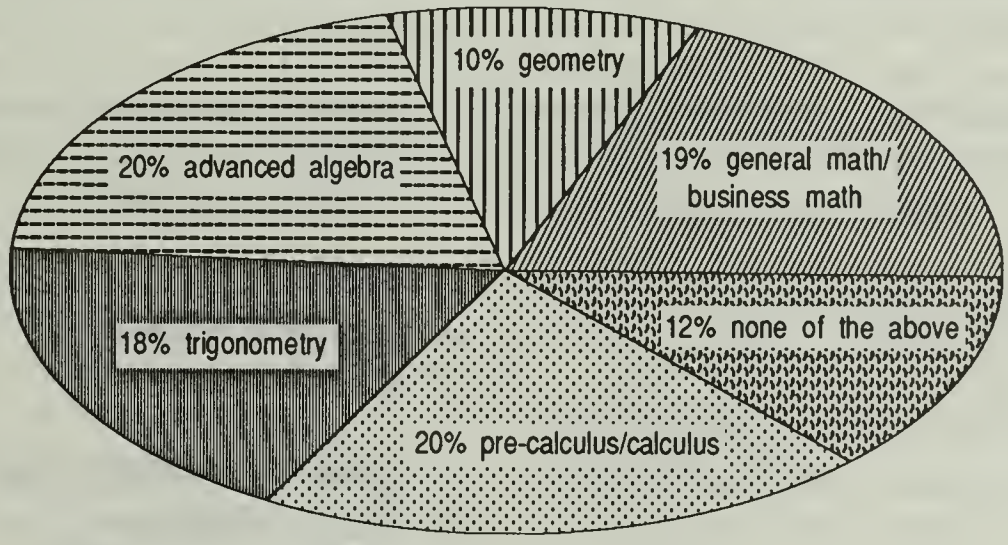


Percent of Teachers' and Students' Responses to Time Taken for Mathematics Homework at Grade 8

Despite the discrepancy in actual time spent, the association between homework and achievement is strong. Teachers who reported that their students spent more time on homework than others had higher school scores in the assessment. Students who reported spending relatively more time on homework scored higher. Over 150 points separate those students who spent less than one hour and those who spent more than 4 hours on homework; the greatest difference, however, is between those students who spent from 1 to 2 hours and those who spent from 2 to 3 hours, a 90-point difference.

These differences in performance that were observed at the eighth grade are more exaggerated at grade 12, where courses vary considerably in the demands placed on students.

STUDENT COURSE ENROLLMENT AT GRADE 12



Despite differences in student ability and course offerings, high school teachers responded to questions concerning instructional practices in much the same way as did eighth grade teachers. However, there is some difference in emphasis. At the high school level, slightly more homework is assigned, less emphasis is placed on worksheets, and more emphasis on end-of-term exams in determining final grades. Calculators are used more frequently (22 percent of teachers reported using them during two or more periods per week, versus 9 percent at the eighth grade level). These are primarily used in trigonometry classes. Computers are used to approximately the same extent, mainly with students of lower ability.

Discussion

It is obvious that mathematical topics that go beyond computation are considered appropriate primarily for more advanced students. Students who do not perform well in mathematics spend most of their time on basic concepts such as fractions, decimals and percentages. Spatial and logical reasoning problems do not constitute an important part of their curriculum.

The differential in achievement between students in different courses in grade 8 is exaggerated by grade 12. In grade 8, there is a 350-point difference between the 23 percent of students who are taking algebra and the 41 percent of students who are taking general math. By grade 12, that difference has almost doubled to a 600-point difference in math assessment scores between the 20 percent of students who are taking general or business math and the 20 percent of students who are taking pre-calculus. Is is difficult to believe that curriculum and instruction does not contribute to that widening difference. Over 60 percent of teachers attributed students' lack of progress in mathematics to indifference or lack of motivation. This judgment is supported by the students themselves. Over eighth grade students as a whole, 46 percent agreed with the statement "Learning mathematics involves mostly memorizing." However, when students were divided according to the courses which they were taking, only 35 percent of those students taking algebra agreed, while the corresponding percentage was 52 percent for students taking general math. Part of the contributing factor to the poor results of students may be what and how they are learning mathematics.

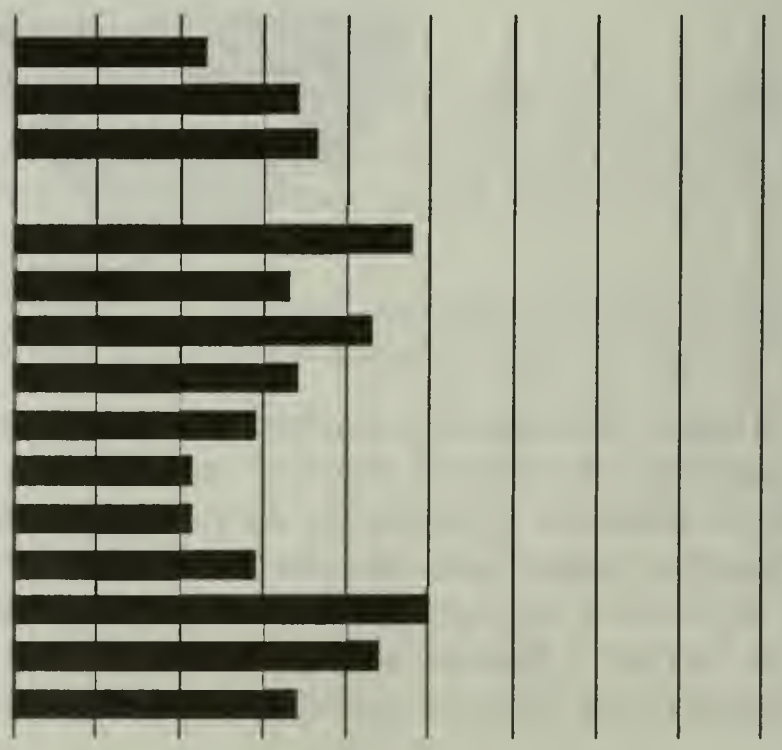
Grade Eight and High School Science

As is true for mathematics, by eighth grade students have begun to study different science content areas; however, unlike mathematics, the differentiation is determined by course sequence rather than by ability.

Information about the curriculum was obtained mainly from teachers, who were asked several questions about their first regularly scheduled science class of the week. Of the eighth grade teachers who responded, the largest proportion (40 percent) were teaching physical science, while 14 percent taught biology, 25 percent earth and space science, and 17 percent general science. These teachers were asked to rate the extent to which the various science subcategories had been covered in their schools from grades 5 through 8. The following pattern occurred.

PERCENTAGE OF EIGHTH GRADE TEACHERS PLACING CONSIDERABLE EMPHASIS ON DIFFERENT SCIENCE TOPICS

- designing scientific investigations 23
- data gathering/reduction 34
- data interpretation 37
- characteristics of life (e.g., classifications of living things, basic life functions, genetics) 48
- health 33
- animal life 43
- plant life..... 34
- ecology and the environment 29
- astronomy 22
- meteorology 22
- geology/natural resources/oceanography 29
- matter 50
- energy 44
- force and motion 34



As seen in the table above, the greatest emphasis is placed on human biology, including health concerns, and on the nature of matter and energy. Relatively little emphasis is placed on space science.

Despite the varied emphases among schools, the relative degree of emphasis on topics in the curriculum was not assocated with higher or lower school performance, except in the case of those topics that referred to different aspects of scientific inquiry. For example, there was a 73-point difference between the scores of schools that did not include designing experiments in their curriculum (6 percent of schools) and those of schools that placed considerable emphasis on it (23 percent of schools). The pattern was similar in response to gathering data and data interpretation, where differences in emphasis were associated with score differences of up to 100 points.

A quarter of the eighth grade teachers responded that their students had a laboratory period once a week. Students in those schools scored almost 100 points higher than those who never had a lab period. On the individual student level, the extent to which students reported doing experiments or laboratory work in their science classes was highly associated with science scores. This association was less evident at the high school level. Although laboratory work was common in high schools, 25 percent of the teachers stated that their classes did not have single lab periods (in contrast to 15 percent at grade 8) and 45 percent stated that their students did not have a double lab period (versus 80 percent at grade 8). High school biology classes were more apt to have frequent single lab periods, while chemistry classes had more frequent double labs.

The association between "doing science" and school performance on the science assessment, particularly at the eighth grade level, was confirmed by questions regarding the availability of equipment. For example, although the extent of equipment (whether students had their own or shared with others) did not seem to affect the school's science score, in schools where eighth grade teachers stated that there was no equipment (12 percent of schools), scores were approximately 100 points lower. A similar effect was found when the equipment was in poor condition. This association was less apparent at the high school level. In addition, although the actual use of computers was not related to performance, the availability of a computer did have some effect on scores. At both levels, schools where no computers were available tended to score lower than others, indicating the importance of resources in achievement.

At the eighth grade level, approximately half the science teachers assign from 1 to 2 hours of homework per week, with another quarter assigning from 2 to 4 hours a week. There is no clear difference in school scores in terms of performance, but there is a sharp difference in terms of individual student performance. In other words, the relatively small (9 percent) group of students who spend more than 2 hours a week on science homework scored approximately 100 points higher on the science assessment than their peers who spend less time. More than school policy, this may reflect personal interest. The 25 percent of students who stated that they were very interested in science also scored significantly higher than others.

Although homework policy does not divide schools in terms of performance, high-scoring schools do differ in terms of the kind of homework assigned. Teachers in higher-performing schools are more likely to require students to collect and organize information. They also tend to assign projects, investigations or experiments for their students to carry out. This was observed at both the eighth grade and the high school level, although the association is stronger at the earlier grade.

In general, sources for instruction and evaluation are traditional. The majority of teachers rely primarily on a single textbook or teacher-made materials for their instructional materials. Few use published kits, curriculum guides or non-texts to any extent. Evaluation is accomplished mainly through objective tests, with 65 percent of eighth grade teachers and 73 percent of high school teachers stating that they rely on these to a great extent. Approximately a third of the eighth grade teachers, and 10 percent more at the high school, rely a great deal on the quality of laboratory work. Another third of eighth grade teachers consider class discussion important in judging their students' progress.

Comments

Higher-performing schools tend to stress "doing science" rather than science content. The association between doing and understanding is particularly strong at the eighth grade level where, perhaps, the school has a larger influence on students' interests and subject area commitment. Certainly, by twelfth grade, it is obvious that a relatively small group of students (approximately 10 percent) are very interested in science, spend time working on it, and are planning a career in science. These students performed extremely well in both the math and science portions of the assessment, and significantly better than they did in reading or social studies. Their scores sharply contrast to those 45 percent of students who believe that science involves mostly memorizing and those 32 percent of students who state that they are not at all interested in science.

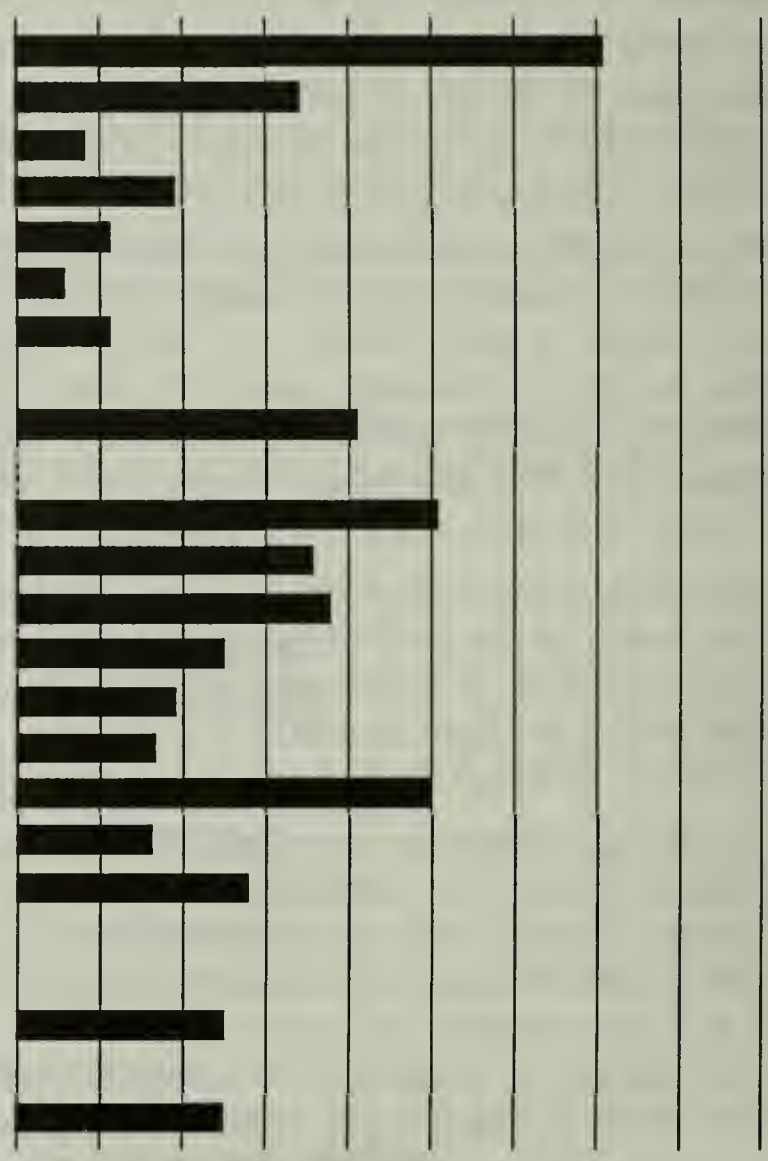
Grade Eight and High School Social Studies

(A full discussion of the social studies results is contained in a separate publication, the *Massachusetts Educational Assessment Program: Social Studies Report.*)

Over three quarters of the eighth grade social studies teachers who responded to the questionnaire teach American history; however, they were asked to respond to the curriculum coverage questions with reference to grades 5 through 8.

PERCENTAGE OF EIGHTH GRADE TEACHERS REPORTING CONSIDERABLE EMPHASIS ON SOCIAL STUDIES TOPICS IN GRADES 5 TO 8

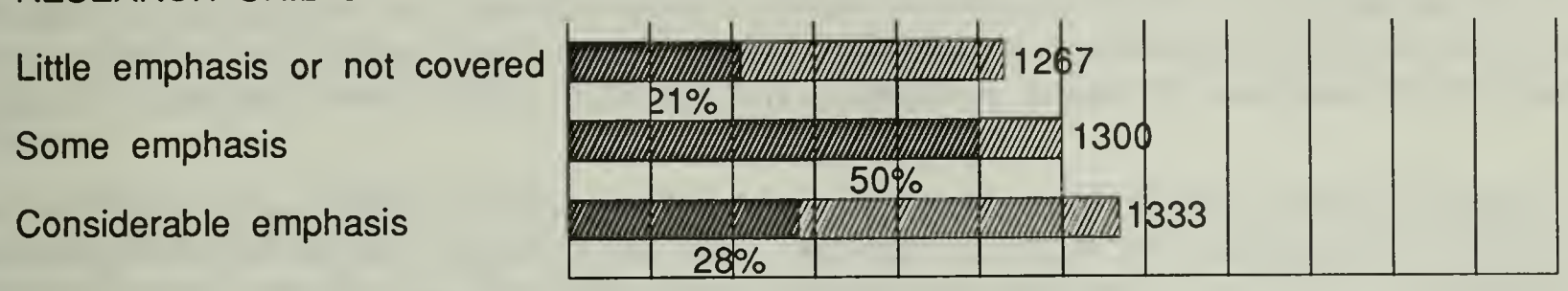
- pre-1865 U.S. history 71
- post-1865 U.S. history 34
- post-1974 U.S. history 8
- world history-classical civilizations 19
- Middle Ages 11
- Renaissance to 1900 6
- 20th Century world history 11
- government (principles, components, processes) 41
- government documents (e.g., Declaration of Independence, Constitution) 51
- citizenship (e.g., rights and responsibilities) 36
- physical geography 38
- human geography 25
- social environment 19
- multicultural environment 17
- map skills 50
- graphic representation 16
- research skills 28
- analyzing information - types of information (facts, assumptions), relationships among ideas 25
- evaluating information - weighing evidence, drawing inferences 25

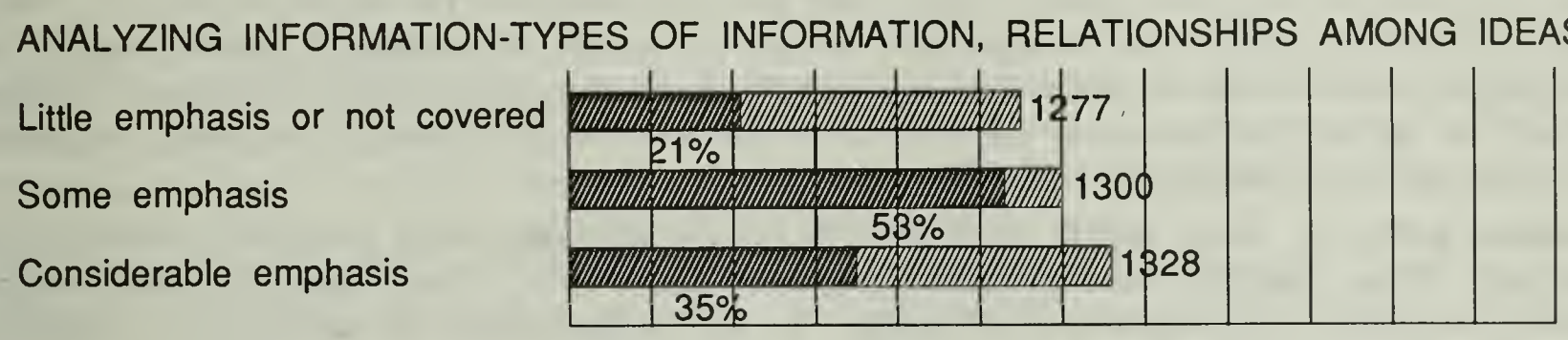


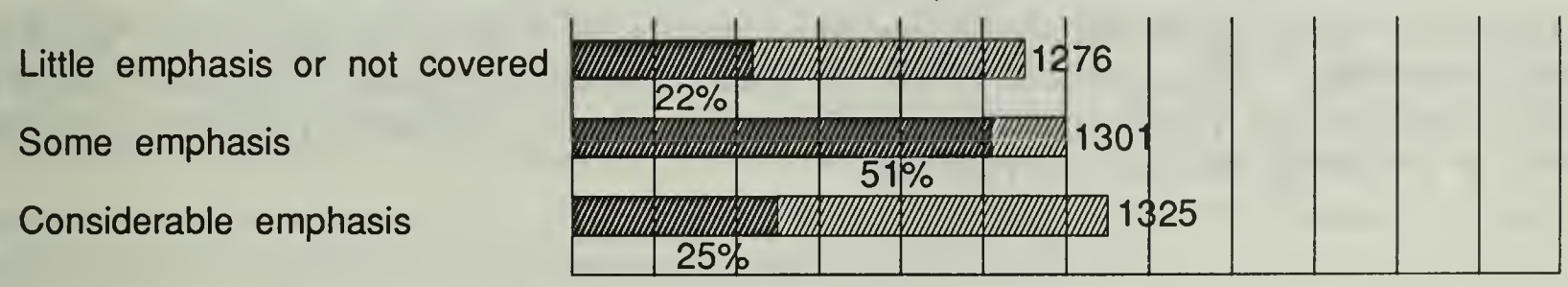
The strongest emphasis is given to U.S. history, citizenship and government in content areas. History other than U.S. history is generally not covered. Physical geography and map and research skills are emphasized. A third of teachers replied that they gave little or no emhasis to human geography, social or multicultural environment or graphic representation.

There was little relationship between the amount of emphasis devoted to different content areas and performance; however, schools that stressed research and thinking skills did perform better than others, as the tables below indicate.

RELATIONSHIP BETWEEN RELATIVE EMPHASIS ON TOPIC AREAS AND PERFORMANCE IN GRADE 8







Instructional Activities. Students in the large majority of schools spend most of their social studies classes taking notes from lectures, reading material from their textbooks and discussing and analyzing material that they have read. This is true at both grade levels, although twelfth grade teachers tend to place more emphasis on lecturing while at the eighth grade level there is relatively more emphasis on the reading of textbooks. This is despite the fact that approximately a quarter of the teachers surveyed stated that more than 25 percent of their students had difficulty reading their current social studies textbook.

There is also a greater tendency at grade 8 to engage students in social studies skills activities such as using maps and globes. Few schools involve their students in role playing, simulation or using the computer. The extent to which students are required to memorize material that they have read is extremely varied, particularly at the high school level. Here, 34 percent of teachers state that they never ask students to memorize, while 31 percent do it on a weekly or daily basis.

Over the set of questions as a whole, it was obvious that a variety of instructional activities led to greater success on the assessment. For example, daily reading from a single text (reported by almost 50 percent of eighth grade teachers) appeared to be a less successful predictor of achievement than daily reading of a variety of materials. Teachers from high-performing schools responded that they used a computer occasionally (20 percent), showed films or videos on a weekly basis (14 percent), engaged their students in role playing once or twice a month (20 percent) and had their students work in small groups approximately once or twice a week (17 percent). Teachers from poorly-performing schools generally did not include these or other activities in their repertoire.

Instructional Resources. The most common source of material for eighth grade teachers is a single textbook or materials that they have developed themselves. However, approximately 20 percent of the teachers responding place a great deal of reliance on multiple texts, current sources of information (e.g., newspapers, magazines), and library resources. Slightly more teachers rely heavily on current and primary sources of information at the high school level. At both levels, teachers' use of multiple texts and library resources was related to their school's performance. This relationship confirms the general relationship between material resources and school performance that has been found in other subject areas and grade levels.

As is the case with science, eighth grade teachers rely primarily on objective tests and short written responses for their evaluation of students. Although more social studies teachers (over 40 percent) state that they place a great deal of emphasis on class discussion, few give any weight to discussion or term papers when determining final grades. These were generally based on the results of quizzes. The small number of teachers who placed no emphasis on project work and essays (5 percent and 7 percent, respectively) came from schools that scored significantly lower than others in the assessment. Replies were similar at the high school level, although teachers at this level tended to rely more heavily on essay tests (38 percent versus 24 percent at grade 8).

Student Attitudes. At the eighth grade level, 29 percent of students look forward to their social studies classes most of the time; the same percentage replied "hardly ever." These attitudes reflect a significant difference in students' achievement of 75 points. At the twelfth grade, the percentage of students with a positive attitude increased to 33 percent, as did the differential in scores between students who enjoyed and who did not enjoy social studies. In this case, the difference in achievement doubled.

On the other hand, approximately 60 percent of students at both levels agreed that "social studies is mainly memorizing." This represents 15 percent more students than agreed to this statement in regard to science or mathematics. Fewer students also believed that social studies was very useful in understanding the world or in getting along in everyday life.

CHAPTER 5: SUMMARY AND IMPLICATIONS

If you ask educators to name the computer's greatest contribution to instruction, they may mention its influence on motivation: how much children will enjoy building and practicing skills through computer software. They may talk about computer simulations and word processing. They may discuss its use in problem solving, and how abilities can be developed by working in such languages as LOGO. Or they may talk about the emphasis on theory and understanding that is possible to achieve through the use of graphics and graphing programs. They will probably not talk about how computer technology has influenced our idea of education itself; and yet, this is possibly its greatest contribution.

That our ideas about education have been influenced by technological models is nothing new. For years, we have used what we might term "a factory model," as we talked about inputs, processes, and outputs. We saw education as a way of transforming ignorance into knowledge. The computer has changed that metaphor. It has led to a renewed interest in learning. For computers to take over the tasks of humans, they must perform the intellectual functions of the most well-informed human, the expert. And so, cognitive scientists, in the service of technology, have begun to examine how the expert gains and uses his or her knowledge.

At the same time, subject matter specialists have begun to examine their own fields from a new perspective. They have tried to delineate the basic logical structures and the key concepts of their areas. In each of the four areas that the Massachusetts assessment has measured, curriculum experts have been suggesting new ideas about learning. Prominent among these ideas are:

1. **The effect of prior knowledge.** Although cognitive psychologists have long recognized the strong role that prior knowledge and beliefs play in learning new material, this is now being recognized by the broader educational community. The metaphor of the child as an empty vessel to be filled with knowledge has been discredited. Instead, educators increasingly recognize that each child enters school with a unique history of ideas and rationale for making sense of the world. In some cases, when school learning is congruent with these beliefs, prior knowledge is an advantage. In others, it serves to confuse. In all cases, for effective instruction, teachers must be aware of what their students know and how they think.

2. **Intelligence as active involvement.** The concept of intelligence as a generalized, quantifiable and immutable characteristic of the individual has been displaced by the idea that intelligence is a characteristic of behavior, resulting from knowledge and experience. People show intelligence by engaging in intelligent behavior. In its turn, intelligent behavior results from active involvement, reflection and adjustment. It is an ongoing process that is dependent upon new experiences and feedback.

3. **Expert behavior as a criterion for performance.** There is a greater distinction between knowing what and knowing how, with the former suggesting passivity, the latter activity. To be an expert, it is not sufficient to know one's subject area; one must be able to apply that knowledge to the solution of problems. The goal of education, then, is the ability to transfer the knowledge that is acquired in one highly structured situation to those unstructured situations that are more typical of everyday life.

These ideas have influenced how students are viewed, what students are taught, how they are taught, and how their learning is measured. Basically, it is a hopeful view, with the goal of creating engaged and interested learners. It assumes a natural desire on the part of children to make sense of and to control their world. In many ways, this report supports these ideas.

More often than not, fourth graders were able to use their knowledge to reason through problems. Although they lacked certain skills and concepts, they exceeded expectations in the way in which they responded to many questions. In this assessment, as in the previous one, they showed a knowledge and understanding of the world that was not the result of direct teaching. Furthermore, they indicated that they generally enjoyed school and believed themselves competent. That feeling of competence and

involvement begins to fade as students grow older. General attitude toward school subjects begins to become more negative while, at the same time, the difference in performance between committed and non-committed learners grows. The gap of 300 points between those who like science and those who do not like it is provocative and worthy of reflection. Classroom experiences must have played some part in its development.

Education does not proceed in a vacuum; consequently, any report on school achievement must include a discussion of what the student brings to the educational process. Among those factors that affect education, the strong effect of home background cannot be ignored. When the values of home are supportive of the values of the school, learning is amplified. A similar effect is associated with language. A fluency with the language of instruction is a prime requisite for understanding the concepts that underlie instruction. Economic and community factors are also important, as poverty takes its physical and mental toll. Furthermore, it is obvious that schools face many problems that are not purely educational. Schools in which drugs are a serious or moderately serious problem (6 percent of eighth grade schools and 29 percent of high schools) perform less well on the assessment, as do schools where students are absent on a regular basis, fight with other students or verbally abuse their teachers.

On the other hand, it would be incorrect to claim that these social problems are the sole determinants of school achievement. The role of the school itself cannot be ignored. Within its own limits it shapes the mental attitudes and capabilities of its students. This report has delineated some of those curricular and instructional practices that are associated with high performance. It suggests that schools do have the power to foster a more engaged and active intellectual commitment on the part of all children.

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Other publications concerning the Massachusetts Educational Assessment Program:

- *Description of Test Content and Reporting Categories*
- *Using the School Report*
- *Social Studies Report*

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